Final Planning Memorandum for the Engineering Evaluation Cost Analysis (EE/CA)

Furnace Creek Area of Operable Unit 1
Black Butte Mine Superfund Site
Cottage Grove, Oregon

Prepared for:

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Section 1

Introduction and Purpose

This planning memorandum for the engineering evaluation/cost analysis (EE/CA planning memo) was prepared as an initial step in developing an EE/CA for a non-time-critical removal action (NTCRA) at the Furnace Creek area of the Black Butte Mine (BBM) Superfund Site Operable Unit 1 (OU1). The OU1 boundary, Furnace Creek catchment area, and other site features are shown in **Figure 1-1**.

In 2007, the U.S. Environmental Protection Agency (EPA) completed a time-critical removal action (TCRA) at BBM to address uncontrolled sources of mercury to Dennis Creek and Furnace Creek. During the TCRA, the following activities were completed:

- Tailings were removed from Dennis Creek and the tailings slope above the creek was stabilized to limit erosion of materials into Dennis Creek.
- Mercury-impacted tailings and soil at the Old Furnace and New Furnace were capped with soil and tailings removed from the Dennis Creek drainage that were determined to have low mercury concentrations.
- Tailings removed during the TCRA activities that had high concentrations of mercury were placed in a repository located at the Main Tailings Pile and capped with soil having low mercury concentrations.

The location of the TCRA focus areas, including the Dennis Creek drainage removal area, Old Furnace area, New Furnace, and the tailings repository are shown in **Figure 1-1.**

In 2009, EPA Region 10 completed a Hazard Ranking System (HRS) evaluation for BBM (Ecology and Environment 2009). Based on the results of the overland discharge/flood component of the evaluation, BBM was added to the National Priorities List (NPL) on March 5, 2010.

In 2012, EPA completed an optimization review of the BBM Superfund Site, which evaluated conditions and identified optimal approaches for conducting the remedial investigation (RI) at the BBM Superfund Site (EPA 2012). In the optimization review, a preliminary sitewide conceptual site model (CSM) was developed that identified several key areas contributing to transport of mercury from BBM to Cottage Grove Lake, including:

- Black Butte Mine Site
- Coast Fork Willamette (CFW) River and Garoutte Creek
- Cottage Grove Lake Wetland Exposed Low Pool
- Cottage Grove Reservoir

From these defined areas, three operable units were established as follows:

- Operable unit 1 (OU1): The Black Butte Mine area and vicinity
- Operable unit 2 (OU2): The CFW River from Big River confluence to Cottage Grove Lake
- Operable unit 3 (OU3): Cottage Grove Lake

The sitewide CSM from the optimization review identified that Furnace Creek may be the largest source of mercury to the downstream watershed. Results of the ongoing OU1 RI, completed between November 2012 and June 2015, document that Furnace Creek is an ongoing and dominant source of mercury from OU1 to the downstream watershed of Garoutte Creek and the CFW River (OU2) and Cottage Grove Lake (OU3). This finding prompted EPA to proceed with a NTCRA to address source control at the Furnace Creek area of OU1.

The purpose of this EE/CA planning memo is to update the CSM specific to Furnace Creek, develop removal action alternatives for the NTCRA, and identify what additional data or studies are needed to complete the EE/CA. Specific objectives for the EE/CA planning memo are:

1. Update the CSM for Furnace Creek (presented in Section 2)
2. Provide rationale for removal action area boundary and develop preliminary removal action objectives (PRAOs) to be considered in the EE/CA (presented in Section 3)
3. Provide and describe the preliminary removal action alternatives identified for the NTCRA at Furnace Creek (presented in Section 4)
4. Identify evaluation steps and/or supplemental field data collection needs (if any) specific to develop the removal alternatives which will be analyzed in the EE/CA (presented in Section 5)

The EE/CA planning memo is focused on the area within the Furnace Creek catchment; however, an evaluation of the former ore processing wastewater handling area, located on the Garoutte Creek floodplain in the vicinity of monitoring well locations MW7 and MW8, has also been included (**Figure 1-1**). Although this area is not within the Furnace Creek catchment, affected soil and groundwater at this location may be related to historic ore processing associated with Furnace Creek.

Section 2

Conceptual Site Model

This section presents the CSM for transport of mercury and other metals from source materials at Furnace Creek to the downstream watershed. The CSM is a tool that is used to organize and communicate information about a site. It provides a summary of where sources of contamination are located, how contaminants will migrate, and where they will migrate to.

The preliminary CSM from EPA's optimization review is a sitewide CSM addressing mercury transport from BBM along the CFW to Cottage Grove Reservoir. Mercury loading to Garoutte Creek and the CFW River is believed to have caused elevated mercury concentrations in the sediment and tissue of fish at Cottage Grove Reservoir and the CFW River. A schematic representation of the sitewide CSM from the optimization review is presented in **Figure 2-1**. In **Figure 2-1**, only the dominant sources of mercury to the downstream watershed are indicated. For example, although the transport of mercury from the Main Tailing Pile as suspended sediment in Dennis Creek does occur, it is not considered a dominant source of mercury to the downstream watershed and is not indicated as such in **Figure 2-1.** The sitewide CSM includes two key components: (1) the release and transport of mercury from the BBM mine site and (2) the mercury methylation process in Cottage Grove Reservoir. The OU1 RI was conducted to evaluate the first component, and EPA is currently evaluating the second component. Surface water and sediment data collected during the ongoing OU1 RI activities identified that Furnace Creek is the most significant source of mercury contamination to Garoutte Creek. The following sections present the current CSM for Furnace Creek that are used for planning of the NTCRA.

2.1 Furnace Creek CSM Overview

The purpose of the Furnace Creek CSM is to describe mercury source materials within the Furnace Creek catchment area and identify the primary contaminant transport pathways from Furnace Creek source materials to Garoutte Creek.

Mercury is present in surface water at Furnace and Garoutte Creek primarily as particulate-bound mercury in the suspended load, and significant transport of mercury occurs along Furnace Creek during periods of higher stream flow during and following rainfall events. Primary sources of mercury within the Furnace Creek catchment area include mine tailings and mercury furnace wastes at the Furnace Creek Tailings Area and the Old Furnace Area **(Figure 1-1).** Dispersion of mercury from the primary source materials results in secondary sources of mercury, including contaminated soil and sediment. Erosion and depositional processes result in mobilization of particulate-bound mercury from the primary and secondary sources into Furnace Creek. During active periods of flow at Furnace Creek, particulate-bound mercury is transported in the suspended load, ultimately discharging to Garoutte Creek. Transport of mercury in the dissolved phase also occurs but to a lesser extent than transport of particulate mercury. The dissolved fraction of mercury in surface water results from leaching of mercury from primary and secondary sources to the creek during rain events and from desorption and dissolution of mercury from sediment in Furnace Creek. Particulate and dissolved mercury concentrations increase during storm events when the greater amounts of sediment are suspended in the water column.

While dissolved mercury is present in groundwater within the Furnace Creek catchment area, groundwater elevation data collected from wells located in the upper and lower reaches of the creek (MW-10 and MW-9) show the groundwater table is below the creek bed throughout the year. This results in a losing stream condition for Furnace Creek along its entire length. Further evidence for the consistently losing stream condition of Furnace Creek includes a rapid decline in the hydrograph after a storm event near the mouth of the creek, indicating a lack of sustained groundwater baseflow contribution. The water level elevation data and ephemeral character (rapid discharge and dry condition of the creek for 6 months of the year) provide clear evidence for the lack of upland groundwater discharge (baseflow contribution) to Furnace Creek resulting in an incomplete pathway of dissolved mercury entering Furnace Creek discharge from contaminated upland groundwater. A graphical depiction of the Furnace Creek CSM is presented in **Figure 2-2.**

Other contaminant transport and exposure pathways associated with the Furnace Creek catchment area, but not considered significant or relevant to the downstream transport of mercury, include direct contact (human and ecological) with primary and secondary source materials and surface water, wind dispersion of particulate-bound mercury, and volatilization of elemental mercury from furnace waste at the Old Furnace area. The purpose of the NTCRA at Furnace Creek is to provide source control for reduction of mercury loading to Garoutte Creek; therefore, further discussion of these less significant transport and exposure pathways are excluded from the Furnace Creek CSM and will be addressed later in the sitewide OU1 RI/feasibility study.

2.2 Contaminant Sources

Primary Sources

Primary sources of mercury within the Furnace Creek catchment area consist of furnace wastes associated with the Old Furnace and tailings at the Furnace Creek Tailings Area. Both of these primary source materials are located on slopes, which are subject to erosion into the channel of Furnace Creek.

Remnants of the Old Furnace are located in the Old Furnace Area, which is located on the north side of Furnace Creek at the location shown in **Figure 2-3.** The foundation of the furnace and a group of vertical pipes of approximately 12-inch diameter are present in the area, partially covered by soil. These vertical pipes are thought to have been a part of the condenser system for the furnace. Miscellaneous steel pipes and other former furnace-related infrastructure are also present in the area of the foundation. This type of furnace operated by placement of a “charge” of ore and fuel into the furnace and burning the fuel to heat the ore to temperatures that caused mercury and sulfur to volatilize. Potential sources of mercury associated with the Old Furnace include residual mercury in, around, or beneath the remnant ore processing the equipment. Residual mercury may be in the form of cinnabar from ore processed at the site or elemental mercury released during the processing of mercury vapors. The extent of furnace wastes are expected to be limited to the location of the Old Furnace remnants and immediate downslope area. During the 2007 TCRA, the area of the Old Furnace and remnant structures were capped with soil and tailings removed during the regrading of the slope above Dennis Creek. The tailings used to cap the Old Furnace area contained less than 23 milligrams per kilogram (mg/kg) mercury, as verified by field screening during the removal action (EPA 2008). The extent of the Old Furnace Area capped during the 2007 TCRA is shown in **Figure 2-3**. Field x-ray fluorescence (XRF) and Lumex mercury data collected at Furnace Creek during the 2007 removal action are presented in **Attachment A**. These data include both mercury concentrations in surface soil prior to capping and mercury concentrations in surface soil after the soil cap was placed. Although the remnants of the Old Furnace remain in place and may contain high concentrations of mercury, the capping soil placed during the 2007 TCRA is expected to limit erosion of furnace wastes and affected soil at the Old Furnace area into Furnace Creek.

Prior to startup of the New Furnace in 1927, ore was processed through the Old Furnace, and spent tailings were discharged directly downslope from the furnace. This was common operational mine practice in the U.S. prior to approximately 1970. The Old Furnace tailings are relatively coarse in texture and have a characteristic pink to red color, which results from oxidation of iron present in the ore. The texture of the tailings ranges generally from sandy gravel to gravel, which when combined with the color makes the tailings relatively easy to differentiate from natural materials. These tailings have been remobilized downstream to some extent and have, in places, covered the channel of Furnace Creek. The approximate extent of tailings at the Furnace Creek Tailings Area is indicated by the hatched area shown in **Figure 2-3.** The extent of the Furnace Creek Tailings Area is depicted in EPA's optimization review (EPA 2012). Information on the thickness of tailings is limited to:

1. Boring for monitoring well MW10 advanced in the upper portion of the Furnace Creek Tailings Area (**Figure 1-1**)

2. Borings MP05, MP06, and MP07, which were advanced during the 2005 Removal Assessment investigation (**Appendix A**).

3. Four test pits or trenches excavated in the Furnace Creek Tailings Area during the 2007 TCRA, including three test pits to depths exceeding 9 feet and one trench of 20-foot length (**Appendix A**). The exact location of the 2007 TCRA test pit locations are not known.

Test pit observations indicated that the thickness of tailings ranged from less than 1 foot (MP04 and MP06) to greater than 9 feet in at least one of the 2007 TCRA test pit locations. The thickness of tailings outside of the boring and test pit locations is not known.

Tailings sampled at the location of the Old Furnace by the Oregon Department of Environmental Quality (DEQ) in 2003 had mercury concentrations up to 2,090 mg/kg; however, the Old Furnace area was capped during the 2007 TCRA to address this area of high mercury concentrations (DEQ 2004; EPA 2008). Samples collected from other areas of the Furnace Creek Tailings Area, collected during the OU1 RI in 2013-2014, indicated that the remaining surface soil in the Furnace Creek Tailings Area had mercury concentrations up to 543 mg/kg (CDM Smith 2014b). Field XRF data collected from the Furnace Creek Tailings Area during the TCRA indicate that tailings, soil, and sediment in this area may have even higher mercury concentrations. The range of mercury concentrations in Furnace Creek Tailings Area is shown in **Figure 2-3.**

Secondary Sources

Mercury-impacted soils within the Furnace Creek catchment are a secondary source of mercury to surface water and groundwater via erosion of soil particles into surface water and leaching of mercury to groundwater. Surficial soils adjacent to tailings areas are impacted by mercury when erosion and depositional process results in dispersion of the tailings into soil. Analysis of incremental surface soil sample TMM that was collected over the Furnace Creek Tailings Area and consisted of soil mixed with tailings indicated an average mercury concentration of 176 mg/kg over the Furnace Creek Tailings Area (CDM Smith 2014b). The location of incremental soil sample TMM is shown in **Figure 2-6**.

Soil underlying the tailings is impacted by mercury when precipitation leaches mercury from tailings and transports it downwards into the underlying soil. Based on discrete-depth soil samples collected at the nearby location MW11 (**Figure 1-1**) at the Main Tailings Area, mercury concentrations in soil attenuate rapidly (generally within 10 feet below the tailings/soil contact) in the clay soil that underlies the tailings. Given that clay is present at boring MW11 to depth of greater than 70 feet below ground surface (bgs) and at MW10 to a depth of greater than 15 feet bgs (total depth explored), migration of mercury leached from tailings in the underlying soil is not a significant transport pathway.

Sediment within the bed of Furnace Creek is another secondary source of mercury to surface water. Analysis of the one incremental sediment sample collected at the downstream end of the Furnace Creek Tailings Area (sediment sample station FC1) indicated an average mercury concentration in bulk sediment of 136 mg/kg (CDM Smith 2014a). DEQ collected grab sediment samples from Furnace Creek immediately downstream of the Old Furnace area in 2008, and mercury was detected at concentrations of 70.2 and 173 mg/kg in the primary and duplicate sediment samples collected at this location (DEQ 2008).

Another potential source of mercury to Garoutte Creek that is located outside of the Furnace Creek catchment area, but may be related to historic ore processing at Furnace Creek, is a historic ore processing wastewater handling area located on the Garoutte Creek floodplain, north of Furnace Creek (vicinity of monitoring wells MW7 and MW8). This area is indicated on **Figure 2-3,** and the monitoring well locations are shown on **Figure 1-1.** Based on interviews with the site resident, during the operating period of the mine, wooden structures were in place at this location to handle ore processing wastewater. The 1952 aerial photograph of the BBM site indicates possible tailings impacts at this location and extending into a former meander of Garoutte Creek (current location of MW8). The 1952 aerial photograph, with a notation of the possible extent of impact from historical wastewater handling processes, has been included in **Appendix B.** Elevated concentrations of mercury were detected in soil and groundwater collected at MW7 and MW-8 during the OU1 RI and may indicate the presence of mercury source materials. Although no direct surface water flow path to Garoutte Creek has been observed, review of the high resolution light detection and ranging (LiDAR) imagery and field reconnaissance shows a possible buried channel originating from the Old Furnace processing area extending to the abandoned meander of Garoutte Creek where MW-8 is located. Mercury contaminated soil in this area may be a source of mercury to groundwater. Preferential groundwater flow in coarser grained alluvium within the abandoned meander is a potential groundwater pathway for dissolved mercury transport to Garoutte Creek outside the Furnace Creek drainage. This pathway is further evaluated in Section 2.3.2.

2.3 Contaminant Transport

Mercury derived from primary and secondary sources is transported via surface water in Furnace Creek to Garoutte Creek in particulate and dissolved forms and to a lesser extend via groundwater. The following sections describe the contaminant transport in the Furnace Creek catchment.

2.3.1 Erosion and Particulate Mercury

The primary transport mechanism of mercury from the Furnace Creek catchment to Garoutte Creek is particulate mercury in surface water. Transport of particulate mercury in surface water occurs via two mechanisms:

1. Erosion of tailings and mercury-impacted soil into the Furnace Creek
2. Re-suspension of mercury-impacted channel bottom sediments into the water column

The relative contribution of each of these mechanisms to the suspended particulate mercury load in Furnace Creek is not well understood. Re-suspension of mercury impacted channel bottom sediment occurs in response to increased flow at Furnace Creek, generally whenever there is a precipitation event. Erosion of tailings or soil into Furnace Creek may occur less frequently, at isolated areas within the catchment area, and in response to larger storm events. Due to the steep topography within the Furnace Creek catchment area, there is potential for erosion of tailings and soil into the Furnace Creek channel throughout the catchment area. This section provides a general description of the Furnace Creek catchment and a description of the transport of particulate mercury via surface water.

Furnace Creek is a small, ephemeral creek that originates as a spring located along the west facing slopes of Black Butte. The creek is approximately 0.4 mile in length, and the total area of the Furnace Creek catchment is 29.8 acres (0.05 square mile). Based on the 2012-2013 monitoring period, the lower half of the Furnace Creek channel was dry and did not have surface flow for approximately 6 months of the year. During the 2013-2015 monitoring period, annual rainfall was abnormally low and flow at the lower half of Furnace Creek only occurred for a few months of the year. Periods when lower Furnace Creek was flowing include:

- November 2012 through May 2013
- February 2014 through May 2014
- December 2014 through April 2015

Uncertainties in the total annual flow at Furnace Creek during dry years should be considered when evaluating the total annual mercury load from Furnace Creek.

The upper portion of the watershed near the spring source has a continuous, albeit small discharge that reliably supplies water for the nearby (b) (6) residence year round. Furnace Creek is a deeply entrenched channel with no smaller tributary stream segment contributions. A headwall scarp about 120 feet upstream of the confluence with Garoutte Creek is present and reportedly the result of a recent manmade high flow event that occurred when active logging in 1998 broke up a small reservoir in the upper portion of the watershed where the (b) (6) residence receives its water supply ((b) (6) 2012). Evidence of the large volume of water flushing through the channel is present in the deeply entrenched, much wider channel that is now populated with 15 year old alder trees. This deep entrenchment is unusual for the minimal stream discharges monitored to date and can only be explained by more catastrophic flow events. The deeply entrenched channel leads to a severely eroded former road bed and a 12-inch culvert that was dislodged and is now emerging from the headwall scarp. Mercury transport via surface water at Furnace Creek was characterized by establishing surface water monitoring station F1 (**Figure 1-1**) on Furnace Creek near the confluence with Garoutte Creek to collect stream flow and water quality data for calculation of the annual mercury load. Continuous stream flow data were collected at F1 using a pressure transducer installed in a stilling pipe that was calibrated to manual stream flow measurements. Surface water quality data were collected through collection of multiple surface water samples at F1 during three storm events in 2013 and 2014. Annual mercury loading to Furnace Creek was calculated using stream flow measurements, mercury concentration data, and the discharge frequency calculation method, as described in CDM Smith 2014a.

Furnace Creek stream flow ranges from no flow during the dry season to up to approximately 3 cubic feet per second (CFS) during large precipitation events. This estimate is based on continuous stream discharge monitoring data collected during the OU1 RI from December 2012 through October 2014. Much higher flow events are expected to occur during 100 year storm events or catastrophic events like the reported failure of the upstream reservoir in 1998.

Water quality monitoring data collected during the OU1 RI indicate that total suspended solids (TSS) and total mercury concentrations increase as the stream flow rate increases during precipitation events. At Furnace Creek, total mercury concentrations ranged from a low of 595 nanograms per liter (ng/L) during the baseline measurement of the March 2013 storm event to a high of 93,800 ng/L during the peak of the larger February 2014 storm event. The flow was approximately 1 CFS during the February 2014 storm event. Based on precipitation statistics at the Cottage Grove 1 NNE weather station for the period of 1914 through 2014, the February 2014 storm event has a 2-year reoccurrence interval (2-year storm event). Higher mercury concentrations in Furnace Creek are expected during larger storm events such as the December 2012 storm when measured flows were 3 CFS. The total and dissolved mercury concentrations in surface water at Furnace Creek monitoring station F1 during the March 2013 and February 2014 events are presented in **Figure 2-4.** The chart in **Figure 2-4** indicates that higher mercury concentrations occur during the rising limb and peak of the stream flow hydrograph. An important finding of the monitoring at F1 was that that total mercury concentrations increase significantly with increased stream flow. This is an important element of the Furnace Creek CSM because high total mercury concentrations and relatively high stream flow rates during storm events result in the largest contribution of mercury to the annual mercury load at Furnace Creek.

2.3.2 Dissolved Mercury

Mercury in dissolved form is primarily transported via surface water and shallow alluvial groundwater in the Furnace Creek catchment to Garoutte Creek although at much lower concentrations than particulate mercury. The following sections describe the transport of dissolved mercury in the Furnace Creek catchment.

Dissolved Mercury in Surface Water

Dissolved mercury in surface water at Furnace Creek occurs via two mechanisms:

1. Precipitation infiltrating and leaching mercury from surficial tailings and bank soils to Furnace Creek during storm events.

2. Dissolution of mercury from sediment suspended in the water column during storm events. This occurs during storm events when the amount of suspended sediment increases and particle surface area is at a maximum.

As described in Section 2.2, soil and tailings in the Furnace Creek Tailings area have relatively high concentrations of mercury. During the OU1 RI, modified Synthetic Precipitation Leaching Procedure (SPLP) tests were conducted on tailings and soil samples collected from the Furnace Creek Tailings and Main Tailings Pile areas to assess the potential for leaching. The results indicated the potential for mercury to leach from soils at concentrations exceeding applicable human health and ecological regulatory screening levels (CDM Smith 2014a). Based on the data, leaching of mercury from surficial tailings and soil in the Furnace Creek catchment may be occurring during precipitation events as precipitation infiltrates the bank soils, resulting in transient flow into Furnace Creek.

During storm events, dissolved mercury concentrations in surface water of Furnace Creek follow the same trend as total mercury concentrations, as shown in **Figure 2-4**. Dissolved mercury concentrations rise quickly to a peak concentration at the peak stream flow and then drop back to baseline concentrations as stream flows drop off. This relationship suggests that desorption and dissolution of mercury as sediment particles are suspended in the water column during storm events may be the primary mechanism for the occurrence of dissolved mercury in Furnace Creek.

Transport of dissolved mercury from upland groundwater underlying the Furnace Creek Tailings Area to Furnace Creek does not occur because Furnace Creek is a losing creek along its entire length and therefore not recharged by upland groundwater (**Figure 2-2**). This is evident during the summer months by the observed diminishing flow of surface water in Furnace Creek from the headwaters near the (b) (6) supply, where creek flow occurs year round, to the downstream reach, where surface flows diminish and eventually cease, below the Old Furnace. Another line of evidence that Furnace Creek is a losing creek is the separation of water levels in Furnace Creek from the groundwater levels at the nearest adjacent upland groundwater monitoring well, MW10. Based on groundwater level monitoring data for MW10, the seasonal high groundwater level is approximately 5 feet lower than the elevation of the bottom of Furnace Creek adjacent to this well. Spatial information for groundwater levels at MW10 and Furnace Creek are provided in **Appendix C**.

Dissolved mercury concentrations in surface water are low compared to total mercury concentrations in surface water of Furnace Creek. As shown in **Figure 2-4**, dissolved mercury during storm events ranges from less than 10 to a maximum of 34 percent of the total mercury concentration in surface water of Furnace Creek. Based on loading estimates for the 2-year period from 2012 through 2014, dissolved mercury contributes approximately 15 percent of the total annual mercury load in surface water of Furnace Creek. Due to the relatively low contribution of dissolved mercury to the total annual mercury load of Furnace Creek, no specific components to address dissolved mercury in Furnace Creek will be included in the Furnace Creek removal action.

Dissolved Mercury in Groundwater at Furnace Creek

As shown in the graphic presentation of the CSM in **Figure 2-2**, groundwater occurs within the Furnace Creek catchment as:

1. Upland groundwater – groundwater occurring within the clay-rich soil underlying the Furnace Creek Tailings Area

2. Alluvial groundwater – groundwater occurring within the shallow alluvium directly below the Furnace Creek channel

Monitoring well MW10 is completed in the upland groundwater system near the Old Furnace area. Monitoring well MW9 is completed within the alluvial groundwater underlying Furnace Creek near the mouth. Well locations are shown in **Figure 2-5.** As shown in **Figure 2-2**, alluvial groundwater is subflow of Furnace Creek and is a perched system as evident by water elevations in Furnace Creek and alluvial groundwater higher than the water table of the underlying upland groundwater system.

Upland Groundwater System

Upland groundwater occurs in a clay-rich soil (clay and gravelly clay) that is hydrothermally altered volcanic tuff of the Fisher Formation (CDM Smith 2014a). Due to the low permeability of the clay soils, recharge rates and groundwater velocity within the upland unit are very low. This is evident by the low recharge rates observed at monitoring well MW10 during well development and sampling. Recharge to upland groundwater occurs as precipitation infiltrates the surficial tailings and underlying soil. As water moves through the tailings or affected soil, leaching of mercury occurs; however, the high clay fraction of the soil has a high capacity to adsorb cations and anions due to greater surface area for attraction and other factors, which limits the mobility of mercury. The relatively high soil to water partitioning coefficients, that were calculated by comparing soil and groundwater concentrations at monitoring wells completed within the upland groundwater system, support the high capacity for soil to adsorb mercury and other metals leached from tailings and affected soil (CDM Smith 2014a).

Dissolved mercury was detected at a concentration of 1,070 ng/L in MW10 in May 2014. The May 2014 results are the only results available for MW10. Prior to May 2014, previous attempts to collect a sample at MW10 in August 2013 and November 2013 were unsuccessful due to insufficient groundwater in the well for sampling. Groundwater levels in the upland groundwater system are generally lowest in the late summer and fall.

Groundwater level monitoring at MW10 shows that the seasonal high groundwater level (April 2014) is approximately 5 feet lower than the elevation of the bottom of Furnace Creek adjacent to this well, which indicates that upland groundwater does not discharge into Furnace Creek. (**Appendix C**). Based on the low permeability soils and the lack of a hydraulic connection between the upland groundwater and Furnace Creek, dissolved mercury from the upland groundwater system is not expected to contribute to mercury loading to Furnace Creek. No components to address mercury transport in the upland groundwater system will be included in the Furnace Creek removal action.

Alluvial Groundwater System

Alluvial groundwater occurs in the channel deposits of Furnace Creek. Due to the coarser grained alluvium, groundwater movement in the alluvial system is expected to be higher than for upland groundwater. The thickness and lateral extent of the alluvial groundwater system is expected to be fairly limited based on the narrow confines of the Furnace Creek drainage and the shallow bedrock evident by outcrops present near the mouth of Furnace Creek. Monitoring points used to characterize the alluvial groundwater system are shown in **Figure 2-5** and include monitoring well MW9 and the buried culvert located near station F1. The buried culvert receives water from the subflow of Furnace Creek, which is believed to be representative of groundwater with the alluvial groundwater system.

Dissolved mercury concentration in the alluvial groundwater system ranged from 9.21 to 139 ng/L, based on samples collected at MW9 and the buried culvert in November 2013 and May 2014. The highest dissolved mercury concentrations were observed in May 2014 when groundwater flow in the alluvial groundwater system is expected to be highest at the end of the wet season.

Based on low dissolved mercury concentrations in alluvial groundwater and the limited thickness and lateral extent, the alluvial groundwater system is not considered a significant source of mercury to the downstream watershed; therefore, no components to address mercury transport in the alluvial groundwater will be included in the Furnace Creek removal action.

Dissolved Mercury in Groundwater at the Former Ore Wastewater Processing Area

Monitoring wells MW7 and MW8 were installed to characterize groundwater at the former ore wastewater processing area on the Garoutte Creek floodplain (**Figure 2-5**). MW7 was completed in floodplain soils at the suspected location of the former wastewater handling basins, and MW8 was installed in a former channel of Garoutte Creek downgradient of MW7. Mercury was not detected in groundwater at MW7; however, at MW8, dissolved mercury was detected at concentrations of 28.9 and 180 ng/L in November 2013 and May 2014, respectively.

Due to the location of MW8 within a former channel of Garoutte Creek, higher groundwater velocities are expected because the channel deposits have much higher hydraulic conductivity than the surrounding floodplain deposits. To address this potential source of mercury to Garoutte Creek, an estimate was made on the contribution of mercury to Garoutte Creek that could come from groundwater discharge through this channel (calculations included in **Appendix D**). The annual mercury loading to Garoutte Creek from groundwater flow through the former channel is estimated at 0.0019 kilograms per year (kg/year), based on maximum mercury concentrations detected at MW8, the dimension of the channel, and conservative estimates on the hydrogeologic properties of the channel deposits. This load contributes 0.3 percent of the total mercury load in downstream Garoutte Creek (0.74 kg/year) and is not considered a significant source of mercury to the watershed; therefore, no components to address mercury transport in groundwater at the former ore wastewater processing area will be included in the Furnace Creek removal action.

2.4 Affected Media

This section provides an overview of the media impacted by mercury within the Furnace Creek catchment and concentrations relative to reference locations, based on the most recent data collected during the OU1 RI. A comprehensive data presentation and evaluation of all data collected from the Furnace Creek catchment during the OU1 RI is presented in CDM Smith 2014a and CDM Smith 2014b.

2.4.1 Soil

Soil sample locations and the range of mercury concentrations detected in surface soil at OU1 are shown in **Figure 2-3**. A background study has not been conducted at OU1; however, as part of the February 2014 Demonstration of Methods Applicability (DMA) study, a 30-point incremental soil sample (GSS) was collected from the floodplain of Garoutte Creek in the area south of the (b) (6) residence, as indicated in **Figure 2-6**. The purpose of this sample was to determine total mercury concentrations in soil at areas outside of the tailing areas. The average mercury concentration in the incremental sample was 11.6 mg/kg. Also during the DMA study, an incremental sample was also collected from the Furnace Creek Tailings Area (sample TMM), and average mercury concentration in the sample was 176 mg/kg, approximately 15 times greater than mercury concentrations detected in the sample collected from the floodplain of Garoutte Creek. Discrete surface soil sample locations sampled during the DMA study show detections of mercury up to 543 mg/kg, indicating hot spot locations in the Furnace Creek catchment having mercury concentrations at approximately 50 times greater than mercury concentrations detected in the sample collected from the floodplain of Garoutte Creek. The location of the incremental samples GSS and TMM are shown in **Figure 2-6**.

2.4.2 Sediment

The range of mercury concentration in sediment at Furnace Creek at locations upstream and downstream of areas disturbed by mining activities are shown in **Figure 2-7.** The upstream sample is designated UFC1, and the downstream sample is designated FC1. Location UFC1 serves as a reference location due to its location upstream of areas disturbed by mining. The range in mercury concentrations for the bulk, <2 millimeter, and <62-64 micron sediment size fractions is shown. Based on **Figure 2-7**, mercury concentrations in sediment at downstream Furnace Creek sample FC1 exceed concentrations at the reference location by 15 to 20 times.

2.4.3 Surface Water

The highest concentrations of total and dissolved mercury on record were detected in surface water at Furnace Creek station F1 during the February 2014 storm event at concentrations of 93,800 and 10,300 ng/L, respectively (**Figure 2-4**). Upstream Garoutte Creek stream monitoring station GU1 (**Figure 1-1**) serves as the reference location for OU1 because it is located upstream of the confluence with Furnace Creek and areas disturbed by BBM mining activities. The maximum total and dissolved mercury concentrations detected at GU1 during the February 2014 storm event were 192 and 8.78 ng/L, respectively. Based on this, total mercury concentrations in surface water at F1 exceeded concentrations at the reference location by approximately 500 times, and dissolved mercury concentrations exceeded concentrations at the reference location by approximately 1,200 times during the February 2014 storm event.

2.4.4 Groundwater

Dissolved mercury concentrations in groundwater at upland groundwater monitoring well MW10, the Furnace Creek alluvial groundwater monitoring well MW9, and the seepage from the buried culvert near F1 are shown in **Figure 2-5**. Dissolved mercury concentrations detected in the background monitoring well MW13 are also shown in **Figure 2-5**. MW13 was selected as the background location for OU1 groundwater due to its location approximately 1 mile upstream along Garoutte Creek. Dissolved mercury concentrations in upland groundwater monitoring well MW10 exceed concentrations at the reference location by 1,300 times. Dissolved mercury concentrations in Furnace Creek alluvial groundwater monitoring locations MW9 exceed concentrations at the reference location by up to 200 times.

2.5 Dominant Source of Mercury to the Downstream Watershed

Furnace Creek is ephemeral, flowing for 4 to 6 months of the year (based on the 2012-2015 monitoring period), and contributes approximately 0.2 percent of the total stream flow in Garoutte Creek, downstream of BBM. However, based on loading calculations for each of the streams monitored during the OU1 RI, Furnace Creek contributes 48 percent of the total annual mercury load to the downstream watershed, representing the largest single contribution of mercury. The 48 percent of the total annual load is conservative (low) estimate because the loading calculations are based on maximum mercury concentrations measured during the February 2014 storm event, which was a moderate intensity storm event that had a 2-year reoccurrence interval (2-year storm event). Percent contributions to the total annual mercury load for Furnace Creek, Dennis Creek, and Garoutte Creek are shown in **Figure 2-8**. The high concentrations of particulate mercury in surface water within Furnace Creek are the primary factor for Furnace Creek to contribute such a high percentage of the mercury load at such low annual flow rates. Mercury concentrations in sediment within downstream Furnace Creek are 15 to 20 times higher than concentrations measured at the upstream Furnace Creek reference location, indicating a significant increase of mercury concentrations in sediment along Furnace Creek within the Furnace Creek Tailings Area. A NTCRA will be conducted at Furnace Creek to address the high concentrations of particulate mercury in surface water and high mercury concentrations in sediment that are discharging from Furnace Creek to the watershed.

No components to directly address dissolved mercury in surface water and shallow alluvial groundwater underlying Furnace Creek will be included in the NTCRA because the contribution of dissolved mercury from these sources to the total annual load is low. However, NTCRA components to address particulate mercury in Furnace Creek are also expected to reduce dissolved mercury concentrations in Furnace Creek.

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Section 3

Furnace Creek Removal Action Area Boundary and Preliminary Removal Action Objectives

The initial identification of the boundary of the removal action for the NTCRA and PRAOs are presented in this section. Rationale for selection of the removal action area boundary is discussed. The removal action area boundaries and PRAOs will be refined, if necessary, during the development of the EE/CA.

3.1 Source Control Action Area Boundary

The Furnace Creek removal action area boundary is shown in **Figure 3-1.** The boundary was selected to include all areas of the Furnace Creek Tailings that are inside the Furnace Creek catchment as defined by the LiDAR dataset, excluding the area of the Furnace Creek Tailings Area that was capped during the 2007 TCRA.

All of the Furnace Creek Tailings that lie within the Furnace Creek catchment are included in the removal action boundary because the tailings have high total mercury concentrations and are located on steep slopes subject to erosion into the channel of Furnace Creek. Once in channel, the tailings are transported in the suspended load of Furnace Creek to the downstream watershed. The entire length of the Furnace Creek Tailings Area is included in the removal action boundary because XRF and Lumex screening data collected from the channel and banks of Furnace Creek during the 2007 TCRA indicate consistently high mercury concentrations in sediment and bank soil extending all the way to the confluence with Garoutte Creek (**Appendix A**). For removal action alternatives involving excavation or containment, the presence of tailings based on visual identification supplement by field XRF (for tailings identification) will be used to define the removal action boundary.

Tailings or affected soil located outside of the Furnace Creek catchment were excluded from the removal area boundary because these tailings are outside the drainage pathway to Furnace Creek and do not contribute to mercury loading of Furnace Creek.

The portion of the Old Furnace that was capped during the 2007 TCRA was also excluded based on the assumption that the capping soil has limited migration of mercury from residual furnace wastes to Furnace Creek.

3.2 Source Control Action Preliminary Removal Action Objectives

The purpose of the removal action at Furnace Creek is to reduce the loading of mercury from Furnace Creek to Garoutte Creek. The following PRAOs have been developed for the Furnace Creek removal action:

1. Reduce the availability and/or mobility of mercury in soil and sediment within the Furnace Creek catchment area to migrate in particulate form to surface water

2. Reduce the migration of Furnace Creek mercury to Garoutte Creek

Removal action alternatives will be evaluated in the EE/CA based on their effectiveness, implementability, and cost. The evaluation of effectiveness will be based to a large degree on PRAO achievement. The performance of the removal action will be measured by:

- Visual confirmation that tailings have been removed or capped for removal action alternatives involving excavation or containment

- Comparison of pre- and post-removal action annual mercury loading in surface water of Furnace Creek at the confluence with Garoutte Creek

Section 4

Preliminary Removal Action Alternatives for Source Control Action at Furnace Creek

4.1 Overview of Removal Action Alternatives

This section provides an overview of the types of removal technologies and process options considered for the Alternatives RA1, RA2 and RA3. Per EPA's Guidance on Conducting NTCRAs under CERCLA (EPA 1993), only the most qualified technologies that apply to the media or source of contamination should be discussed in the EE/CA. Rationale for including the most qualified technologies and process options is discussed below in Sections 4.2 through 4.4 under each alternative description.

Although other technologies and process options may be potentially viable, they are not necessarily the most qualified. The following other technologies and process options that have potential application for the media containing mercury contamination were considered but not included for evaluation within alternatives for the reasons described below.

- Solidification/stabilization (S/S) would require in-situ or ex-situ mixing of binding agents which would physically bind or encloses the contaminants within a stabilized mass and would chemically reduce the hazard potential of a waste by converting the contaminants into less soluble, mobile, or toxic forms. Though this technology can be effective for mercury contamination in solid media, it would have potential implementability issues due to difficulty in economically obtaining and transporting sufficient quantities of binding agents to the remote location, the heterogeneity of the solid source materials that could affect effect blending with binding agents, and the steep topography within Furnace Creek removal action boundary that could affect proper blending especially if conducted in situ.

- Thermal technologies, like vitrification or thermal desorption (in situ or ex-situ), are typically considered for specific applications or soil types with generally low volume for treatment. Thermal technologies can also be effective for mercury contamination in solid media but would also have implementability issues due to the remote locale and steep terrain within the Furnace Creek removal action boundary. Specifically thermal treatment would require surficial tailings and bank soils to be readily accessible for in situ application or excavated for ex situ treatment. Depending on the type of thermal treatment conducted, availability of qualified vendors within a limited construction season are generally more limited than conventional technologies. Although equipment for thermal treatment is designed to be modular and transportable, the size of the equipment may be difficult to transport to a remote locale. In addition, these technologies typically use typically requires a large amount of energy and the utility infrastructure to support them may not be available at the site.

Containment of contaminated solid media using geosynthetic low permeability cover systems is a conventional approach used at many mine sites. However site specific implementation or construction of a geosynthetic low permeability cover would be difficult within the Furnace Creek removal action boundary due to the fact that Furnace Creek is a smaller, high relief watershed. While vegetated geosynthetic low permeability covers can be very effective at eliminating infiltration of precipitation, they have additional implementability issues at higher cost than vegetated soil covers. They are more difficult to construct on steep slopes and require integral drainage layers to prevent failure of the overlying protective layers than simple vegetated soil covers. Delivery of the geosynthetics to the remote location is required whereas soil for covers can be locally obtained; although both kinds of covers require soil to support vegetation the geosynthetic covers require the layers have sufficient depth for frost protection of the drainage systems. These cover systems also require periodic maintenance specific to continued performance of the drainage systems and integrity of the geosynthetics. Given that the PRAOs for this NTCRA relate to containment of particulates, a vegetated soil cover can achieve those objectives similarly to a vegetated geosynthetic

4.2 Alternative RA1

Alternative RA1 uses separation/reclamation/retention best management practices (BMPs) as the strategy to manage particulate-bound mercury to achieve PRAOs. The following general approaches and specific technical measures were considered to be favorable for site-specific conditions to meet the PRAOs:

- Separation approaches to minimize contact of stormwater run-on with contaminated surface soils and sediment
  - Installation of run-on ditch/swale diversion systems upgradient of contaminated surface soils areas
  - Installation of diversion culverts/headwalls within the upper portion of Furnace Creek to Garoutte Creek to bypass stormwater around contaminated sediment areas during low to moderate flow periods
  - Recontouring of slopes upgradient of contaminated surface soil areas
- Reclamation approaches to minimize particulate migration and mobility from contaminated surface soils and sediment to Furnace Creek
  - Recontouring and revegetation of contaminated surface soil and sediment areas
  - Limited surficial treatment of highly contaminated surface soils using chemical agents such as magnesium chloride or potassium permanganate
- Retention approaches to remove particulate-bound mercury in Furnace Creek stormwater prior to entry in Garoutte Creek
  - Installation of a distal stormwater detention basin within Furnace Creek
  - Particulate filtration within the detention basin

- Installation of step pools within Furnace Creek upgradient of the detention basin to slow flow velocity and thus increase sediment deposition

If designed with adequate storage capacity, the in-line detention/sedimentation basin can provide attenuation to flood peaks and can achieve enough retention time for particulate to settle out of the captured stormwater. It is anticipated that the detention/sedimentation basin would be constructed at the downstream end of Furnace Creek near the confluence with Garoutte Creek. Particulate could be better managed if the designed detention basin includes a forebay (if space allows) or by including an oversized sediment trap. It is anticipated that the detention/ sedimentation basin would be unlined and unvegetated. The potential for the formation of methyl mercury in detained stormwater will be evaluated under this alternative, and mitigation measures for methyl mercury, if needed, will be included in the design.

Implementation of clean surface water diversion would be a viable separation approach, which would bypass stormwater around contaminated sediment areas during low to moderate flow periods.

4.3 Alternative RA2

Alternative RA2 uses containment approach to limit erosion of mercury source materials into Furnace Creek, thus, meeting the established PRAOs. The following general approaches and specific technical measures were considered to be favorable for site-specific conditions to meet the PRAOs:

- Containment approaches to minimize or limit contact of stormwater run-on with contaminated surface soils and sediment
    - Recontouring of surface tailings and contaminated surface soil areas
    - Installation of vegetated soil cover and creek stabilization
    - Implementation of erosion and sediment control BMPs

The existing surface tailings and contaminated surface soil areas would be graded to the extent practicable for the installation of a containment system. The material for vegetated soil cover would be selected based upon material properties, onsite availability, and local availability as well as accepted practice for the construction of mine covers. The vegetated soil cover is a multi-layered containment system, which would generally include a barrier protection layer, growth media layer, and vegetative layer.

The barrier protection layer material serves as a buffer between the growth media and the rooting zone above the contaminated soils. This layer helps control the flow of water, provides water storage for vegetation, and provides an expanded root zone. The growth medial portion of the vegetated soil cover has relatively high organic content, which would allow for increased moisture retention to help the vegetation through drought periods. The growth media would be compatible with local soils to be capable of supporting native vegetation. The vegetative layer is one of the most important elements for stability of the containment system. The vegetative layer will minimize erosion of the underlying soils as well as retain precipitation and promote evapotranspiration. Before establishment of the vegetative layer on the covers, use of erosion control measures would limit erosion and subsequent transport of covers soil during storm events. Lateral stormwater bench swales would be constructed on the vegetated soil covers to intercept flows from the upgradient slopes and convey them into the channel of Furnace Creek.

For steep areas near the creek, engineered materials, like geogrid/geoweb cellular confinement system, would be used as a barrier protection layer of the containment system. Another robust earth stabilizing approach, such as articulated concrete block system or turf reinforced mats, may be needed to prevent scour and subsequent erosion of the creek bed.

4.4 Alternative RA3

Alternative RA3 uses removal, onsite disposal, and reclamation along with erosion and sediment control BMPs as the strategy to manage particulate-bound mercury to achieve PRAOs. These approaches would remove source material from the Furnace Creek catchment area, reduce transport of particulate-bound mercury into Furnace Creek surface water, reduce the potential for leaching of metals into groundwater, and reduce surface water and shallow groundwater interaction with contaminated sediment in the bed of Furnace Creek. The following general approaches and specific technical measures were considered to be favorable for site-specific conditions to meet the PRAOs:

- Removal approaches to significantly minimize or eliminate the contact of stormwater run-on with contaminated surface soils and sediment
    - Mechanical excavation
    - Pneumatic excavation
- Onsite disposal repository

Under this alternative, the primary source of mercury contamination (i.e., surface tailings and mercury-impacted soils within the Furnace Creek catchment area) would be mechanically excavated. If the actual slope of the excavation is steeper than the maximum allowable slope, then proper mitigation measures, like cutting back the actual slope or sloping and benching system, would be performed. Dewatering of excavated tailings or mercury-impacted soils would be performed to the extent practicable prior to onsite disposal. Pneumatic excavation could be used in areas where accessibility to surface tailings and mercury-impacted soils using standard equipment would be difficult. Horizontal and vertical delineation of surface tailings and mercury-impacted soils would be required prior to commencing the excavation for disposal. Proper delineation would also be required to approximately calculate the excavation volume for disposal and design an onsite repository.

Detailed topographical maps from the LiDAR data set would be used to locate a suitable location for an onsite disposal repository. The design of a disposal facility would vary significantly based on the location of the disposal repository, i.e., bottomland areas versus hillside or a ridgetop. Based on the existing topographical maps, areas with 12 percent grade or less are located north of the existing tailings repository and upstream of the confluence of Dennis Creek and Garoutte Creek (outside of FEMA flood Zone A) [**Figure 1-1**].

Ridgetop Disposal Repository Concept

The ridgetop would be leveled off through excavation and removal or relocation of the native soil and rock materials to expand and create a level surface foundation for the disposal repository. Over-excavation and compaction of the ridgetop material would be performed as needed to create stabilized fill around the perimeter of the disposal repository location. This level surface would then be used to construct the disposal repository.

Hillside Disposal Repository Concept

The hillside disposal repository concept would be on a shallower portion of the hillside or at the bottom of a hillside with progressively steepening slopes on the hillside. The shallower area of the hillside would be excavated using heavy machinery to create a level surface. The steeper areas of the hillside also would be excavated as needed to create either a benched slope or shallower slope to create disposal repository capacity and lessen the slopes on the disposal repository cover.

Bottomland Disposal Repository Concept

The bottomland disposal repository concept would be on a bottomland area surrounded by steep hillsides. The shallower areas within the bottomland would be leveled using heavy machinery or blasting to create a level surface. Over-excavation and compaction of the bottomland material would be used to create stabilized fill around the perimeter of the disposal facility site. This level surface would then be used to construct the disposal repository.

This repository would be contained using a similar containment system as described for Alternative RA2 in Section 4.3.

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Section 5

Identification of Information Needed to Develop the EE/CA

The following section presents an overview of the information needed for development of the EE/CA, identifies data gaps, and provides recommendations for additional data collection.

5.1 Evaluation of Existing Information and Identifying Data Gaps Related to Delineation of Source Materials at Furnace Creek

The CSM presented in this memorandum is a baseline of the existing conditions within the Furnace Creek catchment and provides the basis for the removal action objectives in the EE/CA. The CSM is based on a limited amount of data that were collected during the 1998 site inspection, DEQ's 2003 reconnaissance soil sampling, EPA's 2005 removal assessment investigation, EPA's 2007 TCRA, and OU1 RI activities completed from 2012 through 2014 (Ecology and Environment 1998; DEQ 2004; Ecology and Environment 2006; EPA 2008; CDM Smith 2014a; CDM Smith 2014b). This section provides a discussion of specific data used in the CSM, the completeness of the data, data gaps, and an assessment of how critical the data gaps are for development of the EE/CA. The discussion is organized by the following key evaluation steps of the CSM:

- Delineation of source materials (the primary data need for the EE/CA)
  - Furnace wastes
  - Tailings and mercury-impacted soil
  - Sediment
- Evaluation of transport pathways
  - Erosion of tailings and soil and suspension of particulate mercury in surface water
  - Leaching of mercury from tailings and soil and transport of dissolved mercury in surface water and groundwater
  - Suspension of particulate mercury in surface water
  - Dissolution of mercury from suspended sediment in surface water

- Mercury inputs to Garoutte Creek
  - Mercury in sediment discharging to Garoutte Creek
  - Total and dissolved mercury in surface water discharging to Garoutte Creek
  - Dissolved mercury in shallow alluvial groundwater discharging to Garoutte Creek

Delineation of Source Materials

Furnace wastes are limited to the Old Furnace, which is well defined based on the visible remnants of the Old Furnace structures. The area of the Old Furnace capped during the 2007 TCRA is documented by a post-removal action survey. The outline of the 2007 cap, based on the post-removal action survey, is shown in **Figure 3-1**. Based on this figure, part of the Old Furnace capped area lies within the Furnace Creek catchment area. Although confirmation soil sampling of the capped area was conducted in 2007 (results included in **Appendix A**), the analysis of the confirmation samples was done with XRF and Lumex methods without correlation to total mercury analysis by laboratory methods, so the accuracy of the confirmation sampling results is uncertain. No post-2007 TCRA inspection has been completed to evaluate the effectiveness of the cap to provide containment of the furnace wastes, tailings, and impacted soil at the Old Furnace Area. Because the 2007 TCRA cap of the Old Furnace Area consisted of tailings from the main tailings pile, it may not be possible to visually distinguish the capping tailings from the underlying furnace wastes and tailings.

Options to address this data gap include (1) visual inspection of the 2007 TCRA cap for evidence of erosional areas or exposed materials associated with the Old Furnace, (2) soil sample collection from the capped area and analysis for mercury by XRF supplemented by laboratory analysis, or (3) adding the area of the 2007 TCRA capping in the removal action area. The purpose of the sampling and analysis would be to verify that no exposed tailings or soil are present in the portion of the 2007 TCRA cap that falls within the Furnace Creek catchment area and that concentrations do not exceed the 2007 TCRA cap screening level of 23 mg/kg. If the data gap is not addressed, the EE/CA could make the conservative assumption that the area of the 2007 TCRA capping be included in the removal action area boundary.

The current understanding of the extent of the Furnace Creek Tailings Area is based on the extent of tailings presented in the optimization review, which was provided to EPA by DEQ, XRF and Lumex data collected during the 2005 removal assessment investigation and 2007 TCRA, and soil sampling conducted during the DMA investigation in 2014 (EPA 2012; EPA 2008; CDM Smith 2014b). Existing soil sample data to define the lateral extent of tailings and mercury-impacted soil in the upper reach of Furnace Creek is generally sufficient; however, the downstream reach of Furnace Creek has no soil sample data to confirm the lateral extent of tailings and affected soil within the catchment area. Data to constrain the vertical extent of tailings in the Furnace Creek Tailings Area is limited to monitoring well MW10; the 2005 removal action assessment borings MP05, MP06, and MW07; and the four test pits/trenches excavated during the 2007 TCRA, all located in the upper portion of the Furnace Creek Tailings Area. The lateral extent of the tailings in the downstream reach of Furnace Creek and the vertical extent of tailings over much of the Furnace Creek Tailings Area is a data gap. The significance of this data gap relative to the EE/CA is that due to the lack of detailed information on the lateral and vertical extent of tailings, conservative estimates will be required that may bias the evaluation of alternatives against the excavation or capping alternatives. The consequences of these data gaps vary based on the alternative. For example, Alternative RA3 is most affected by the data gap because of uncertainty in excavation volume due to the combined data gaps of the lateral extent and depth of tailings. Alternative RA2 is less affected because the uncertainties in containment area are related only to the extent of the tailings. Effects to Alternative RA1 are minimal because the alternative relies primarily on capture of surface water and that is not affected by the data gaps of lateral extent and depth of tailings. If the EE/CA is conducted without resolving this data gap, then it would need to be addressed during the design phase.

Mercury concentrations in sediment at Furnace Creek have been characterized by XRF and Lumex data collected along Furnace Creek during the 2007 TCRA, sediment samples collected by DEQ from Furnace Creek near the Old Furnace site, and incremental sediment samples collected during the OU1 RI in 2013 from locations upstream of the Furnace Creek Tailings Area and downstream near the confluence with Garoutte Creek (EPA 008; DEQ 2008; CDM Smith 2014a). The sediment is fairly well characterized by these data and indicates continuously elevated mercury concentrations along Furnace Creek from the Old Furnace area to the confluence with Garoutte Creek.

Evaluation of Transport Pathways

The surface water samples collected at Furnace Creek station F1 during storm events in March 2013 and February 2014 and flow monitoring data collected from 2012 through 2015 provide a good data set for evaluation of the transport of particulate mercury via erosion of riverbank tailings and soil and re-suspension of sediment in surface water of Furnace Creek. While these data do not differentiate the degree to which bank erosion or re-suspension of sediment contributes to the suspended load in Furnace Creek, the data are sufficient to identify that these two transport mechanisms are responsible for the high particulate mercury loads in Furnace Creek. One data gap associated with the transport of particulate mercury in surface water of Furnace Creek is mercury concentrations during high stream flows, outside of the existing data set. While this information would improve understanding of the mercury loading to Garoutte Creek over time, it is not critical for evaluation of removal action alternatives in the EE/CA.

Leaching of mercury from tailings and mercury-impacted soil is well characterized by SPLP testing results for soil samples collected at the Furnace Creek Tailings Area monitoring well MW10 and from SPLP test results at other locations in OU1 (CDM Smith 2014a). Total mercury concentration data collected from soil samples at MW10 provide a good understanding on the downward transport of mercury leaching from tailings into the underlying soil. There are no significant data gaps related to this pathway.

The surface water samples collected at Furnace Creek station F1 during storm events in March 2013 and February 2014 and flow monitoring data collected from 2012 through 2015 provide a good data set for evaluating the dissolution of mercury from increased suspension of sediment in the water column during higher flow events. While additional surface water data collection at F1 would improve understanding of this process, it is not critical for completing the EE/CA.

Samples collected at MW9 and the buried culvert near F1 in November 2013 and May 2014 provide a good dataset for understanding the dissolved mercury concentrations in alluvial groundwater underlying Furnace Creek. One data gap associated with the alluvial groundwater pathway is the hydrogeologic data groundwater discharge rate to Garoutte Creek. Additional drilling and installation of test wells would be required to determine the hydrogeologic parameters of the alluvial system (i.e., width and depth of alluvial system, transmissivity, hydraulic gradient). Although this information would improve understanding of baseline conditions, it is not critical for completing the EE/CA.

Mercury Inputs to Garoutte Creek

The incremental sediment sample FC1 was collected in 2013 at a location just above the confluence with Garoutte Creek and provides a good baseline of the concentration of mercury in sediment that is currently discharging to Garoutte Creek. The surface water samples collected at F1 during storm events in March 2013 and February 2014 provide a baseline for particulate and dissolved mercury concentrations in surface water currently discharging to Garoutte Creek. Groundwater samples collected at MW9 in November 2013 and May 2014, supplemented by seepage water samples collected from the buried culver near F1, provide information on the mercury concentrations in groundwater discharging to Garoutte Creek at the beginning of the wet season and late in the wet season. There are no data gaps related to mercury discharges to Garoutte Creek that are critical for completing the EE/CA.

5.2 Evaluation of Existing Information and Identifying Data Gaps Related to Preliminary Removal Action Alternatives

This section presents the evaluation of existing information and data for the Furnace Creek catchment area and focuses on identifying data gaps or information needed to evaluate approaches defined by the specific technologies and process options identified for Alternatives RA1, RA2, and RA3. A comprehensive list of data gaps or information needed to complete the evaluation of removal action alternatives in the EE/CA is presented in **Table 5-1**. While the data and information needs listed in **Table 5-1** will need to be addressed before design of the removal action, they can be overcome by making assumptions that are sufficient for an EE/CA. Following is a discussion of the critical data gaps or needs, justification, and recommended data collection that would be required for completing the evaluation of removal action alternatives.

Alternative RA1

The following critical data gaps or information would be needed to evaluate approaches defined by the specific technologies and process options identified for Alternative RA1:

- <u>Detention/Sedimentation Basin:</u> A storm hydrology study would be required to evaluate the sizing of detention/sedimentation basin for particulate management under retention approaches to remove particulate-bound mercury in Furnace Creek stormwater prior to entry in Garoutte Creek. Existing data from the 2012-2015 precipitation and flow monitoring at Furnace Creek and historical precipitation data from area weather stations could be used as the basis for the storm hydrology study and no additional site-specific data collection would be required.

- <u>Lateral Extent of Contamination:</u> Accurate knowledge of the lateral extent of surface tailings and mercury-impacted soils within the Furnace Creek watershed is needed to determine the placement of detention/sedimentation basins. Any tailings within the Furnace Creek catchment downstream of the selected detention/sedimentation basin would need to be addressed by the containment or removal measures described under RA2 and RA3. The extent of tailings would be delineated by visual mapping. Surface soil samples would be collected for analysis by XRF supplemented by laboratory analysis to verify visual mapping of tailings. The mapping and soil sampling should be conducted along a series of transects that extend up each bank from Furnace Creek to the edge of the tailings or catchment.

Alternative RA2

The following critical data gaps or information would be needed to evaluate approaches defined by the specific technologies and process options identified for Alternative RA2:

- Lateral Extent of Contamination: Accurate knowledge of the lateral extent of surface tailings and mercury-impacted soils within the Furnace Creek watershed is needed to determine the extent of cover required for containment approaches to minimize or limit contact of stormwater run-on with contaminated surface soils and sediment. Means and method of collecting the data is similar to what is described for Alternative RA1.

- Geotechnical Data: Soil type and particle size analysis, permeability and hydraulic conductivity, compaction, plasticity index, and slope stability analysis would be required for the evaluation of vegetated soil cover. The main focus of the geotechnical data would be to evaluate stability of soil covers on the steep slopes. A few representative samples of each material (surface tailings, mercury-impacted soils, and borrow soil) would need to be collected for geotechnical analysis.

Alternative RA3

The following data gaps or information would be needed to evaluate approaches defined by the specific remedial technologies and process options identified for Alternative RA3:

- Lateral Extent of Contamination: Accurate knowledge of the lateral extent of surface tailings and mercury-impacted soils within the Furnace Creek watershed is needed to determine the extent of removal required for a removal approach to significantly minimize or eliminate contact of stormwater run-on with contaminated surface soils and sediment. Means and method of collecting the data is similar to what is described for Alternative RA1.

- Depth of Contamination: Accurate knowledge of the vertical extent of surface tailings and mercury-impacted soils within the Furnace Creek watershed is needed to determine the extent of removal required. The thickness of the tailings can be characterized by excavating test pits or borings along the slopes above Furnace Creek and using visual observations supplemented by soil sample collection, XRF, and laboratory analysis to determine tailings thickness at each test pit/boring location.

- Onsite Repository: It would be necessary to research potential onsite disposal locations based on the existing topographical maps from the LiDAR data, geology, accessibility, and ownership. The following minimum considerations for repository locations would be made:

- Locations within the extent of topography surrounding the Furnace Creek watershed area that were mapped by LiDAR methods
- Locations with a suitable slope and capacity for repository
- Locations near existing roads
- Locations outside of the floodway of major creeks or streams and predominantly outside the delineation of mapped perennial drainages.

- Geotechnical Data: Similar data needs as described for Alternative RA2. The main focus of the geotechnical data would be to evaluate stability of repository slopes and soil covers. A few representative samples of each material (surface tailings, mercury-impacted soils, and borrow soil) would need to be collected for geotechnical analysis.

5.3 Recommended Field Data Collection or Studies

Section 5.2 described the information needed to evaluate RA1, RA2, and RA3 and recommended data collection activities or studies to obtain the information. Although this information will be needed prior to the completing the design of the NTCRA, the data gaps related to RA1, RA2, and RA2 can be overcome by making conservative assumptions that are sufficient for an EE/CA. **Table 5.1** provides a comprehensive list of the information needs for each removal approach, the availability of the information, rationale for why the information is needed, and implications to the EE/CA if assumptions are used instead of collecting site specific information.

Section 6

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Figures

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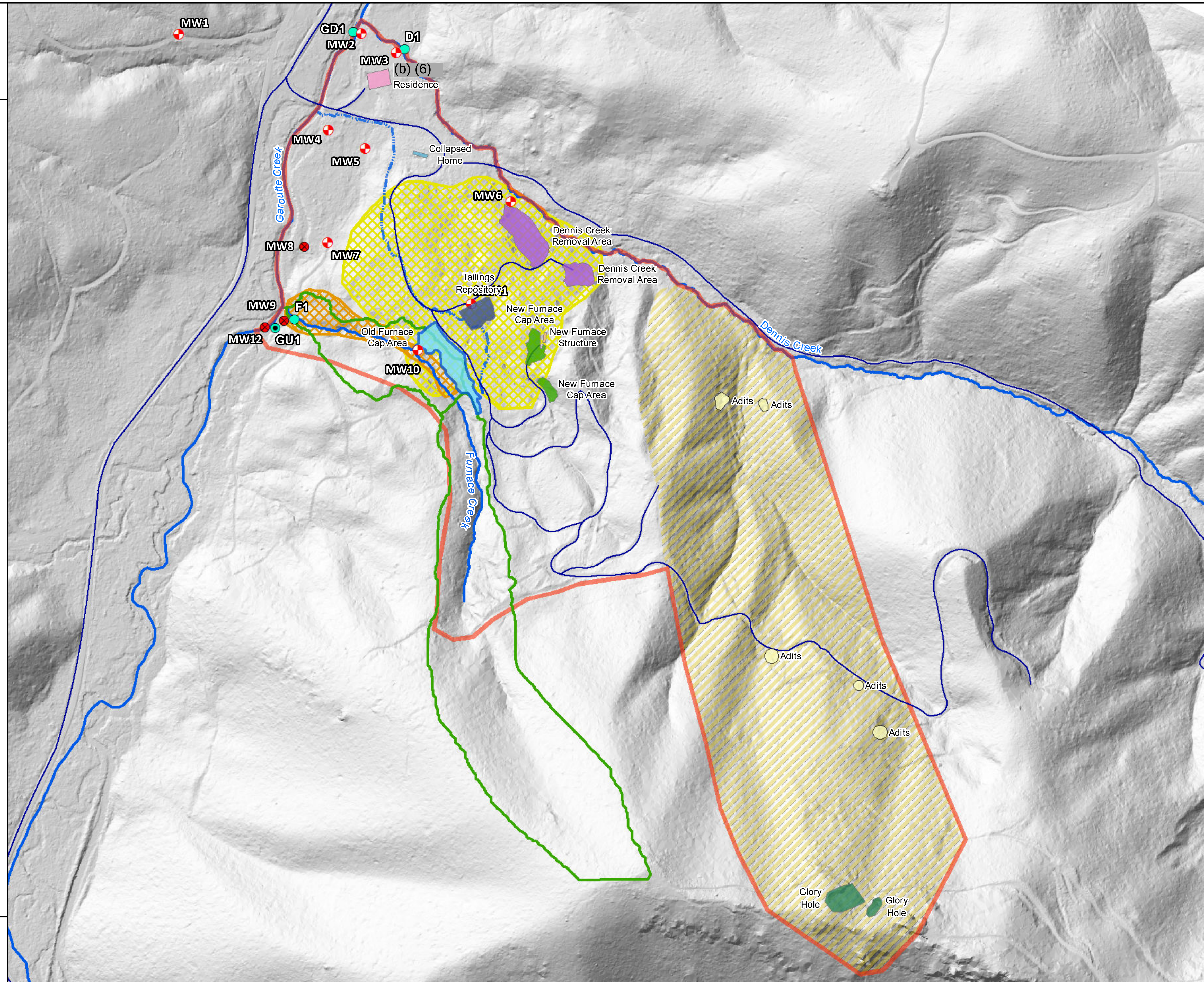
Figure 1-1

Black Butte Mine Superfund Site
Site Location Map

Legend

- Groundwater Monitoring Well (Sonic)
- Groundwater Monitoring Well (Hand Driven)
- Surface Water Monitoring & Sediment Sampling Location
- Surface Water Monitoring Station
- Road
- Creek/Stream/Drainage
- Intermittent Creek/ Stream/Drainage
- OU1 Boundary
- Furnace Catchment Boundary
- Approximate Extent of Old Furnace Area Capped During the 2007 Removal Action
- Main Tailings Pile
- Furnace Creek Tailings Area
- Cinnabar Ore Zone
- New Furnace Cap Area
- Adits
- Collapsed Home
- Glory Hole
- New Furnace Structure
- (b) Residence
- Dennis Creek Removal Area
- Tailings Repository



N

0 250 500 1,000

Feet

1 inch = 500 feet

EA

CDM Smith

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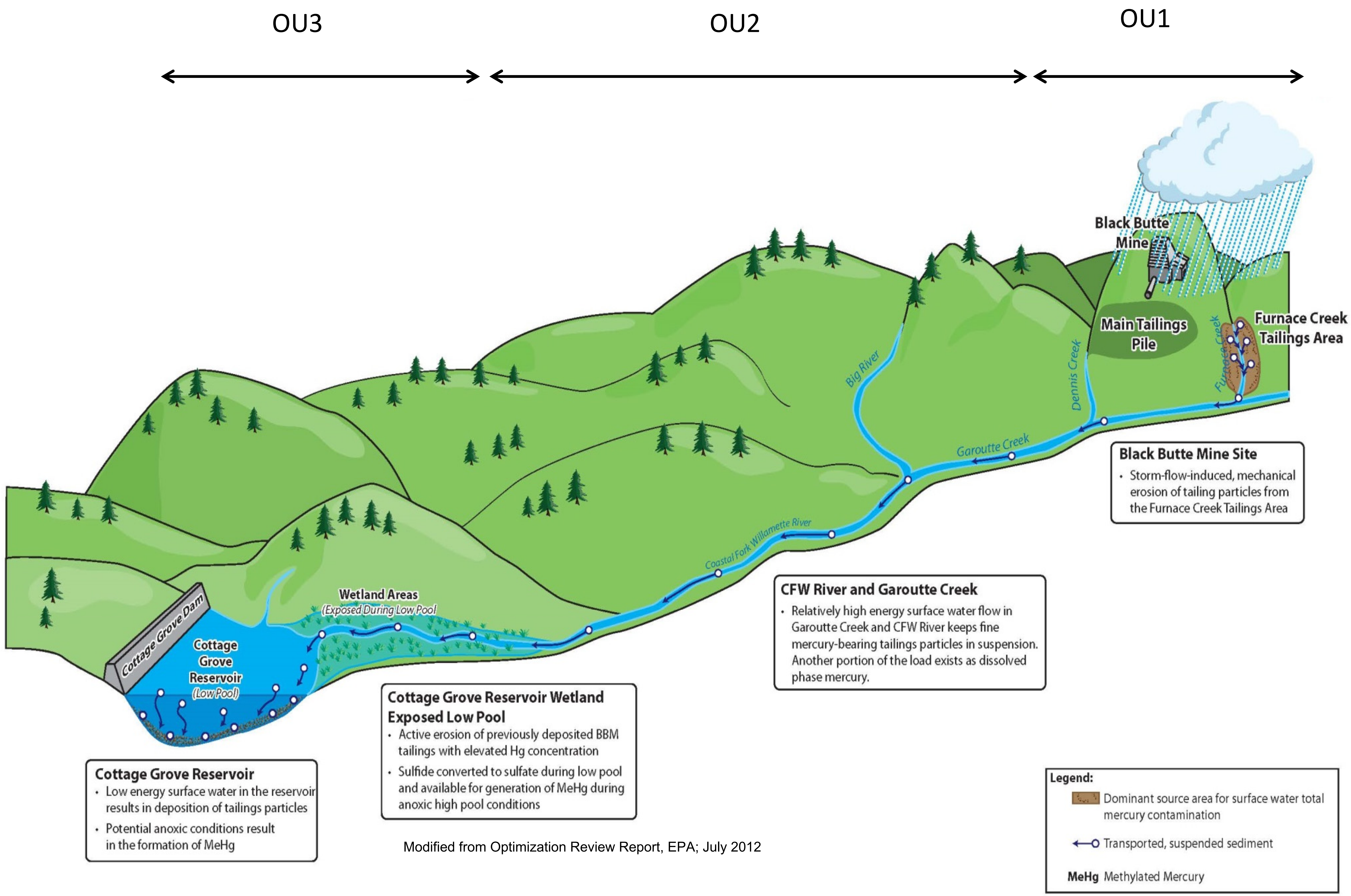

Modified from Optimization Review Report, EPA; July 2012

EA CDM Smith

Black Butte Mine Superfund Site

Figure 2-1
Schematic of Conceptual Site Model

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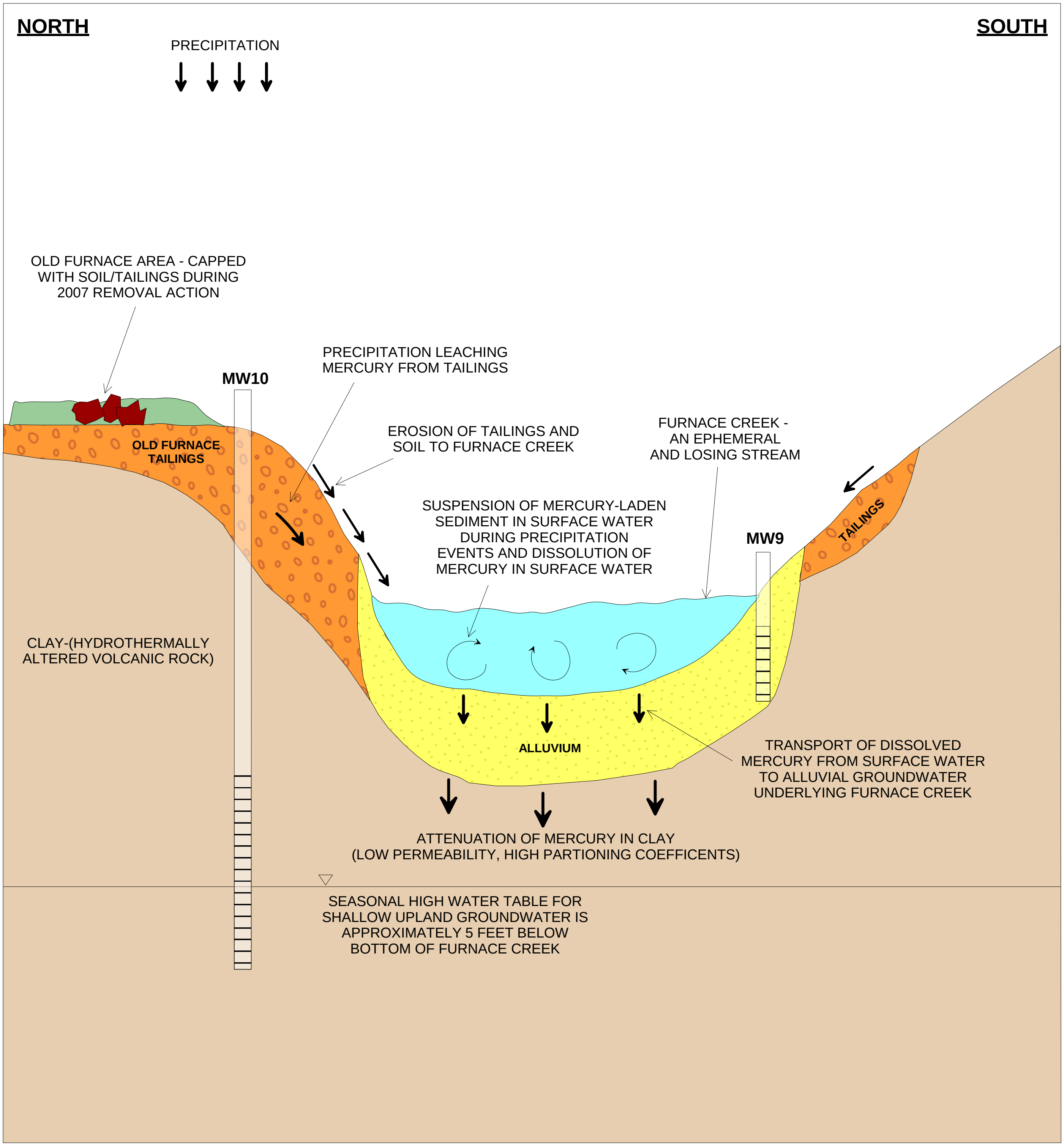

NOT TO SCALE

EA CDM Smith	Black Butte Mine Superfund Site	Figure 2-2 Furnace Creek Conceptual Site Model

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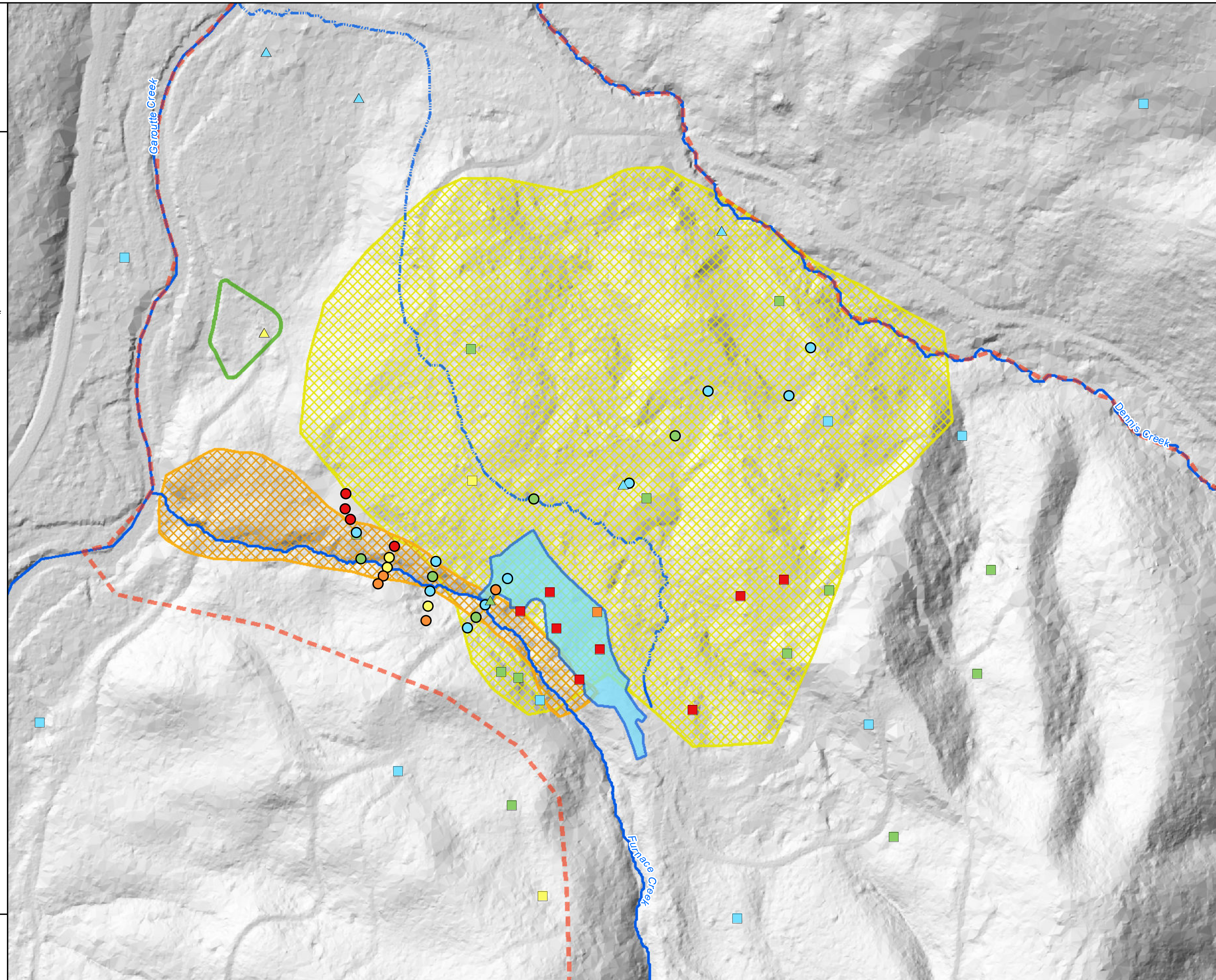
Figure 2-3

Black Butte Mine
Soils Sampling Location Map
Mercury Concentrations



Legend

- EPA Monitoring Well Soil Sample Locations (2013/2014 Data)
- EPA Soil Sample Locations (Feb 2014 Event)
- DEQ Soil Sample Locations (2003)
- Creek/Stream/ Drainage
- Intermittent Creek/ Stream/Drainage
- OU1 Boundary
- Main Tailings Pile
- Furnace Creek Tailings Area
- Approximate Extent of Old Furnace Area Capped During the 2007 Removal Action
- Historic Ore Processing Wastewater Handling Area

Soil Concentrations for All Samples

Mercury (mg/kg)

- ≤ 10
- >10 - 50
- >50 - 100
- >100 - 200
- >200

Note: 2003 DEQ soil sample locations within the footprint of the 2007 removal action capping are no longer exposed at the surface.

N

0 100 200 400

Feet

1 inch = 200 feet

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8/4/2015

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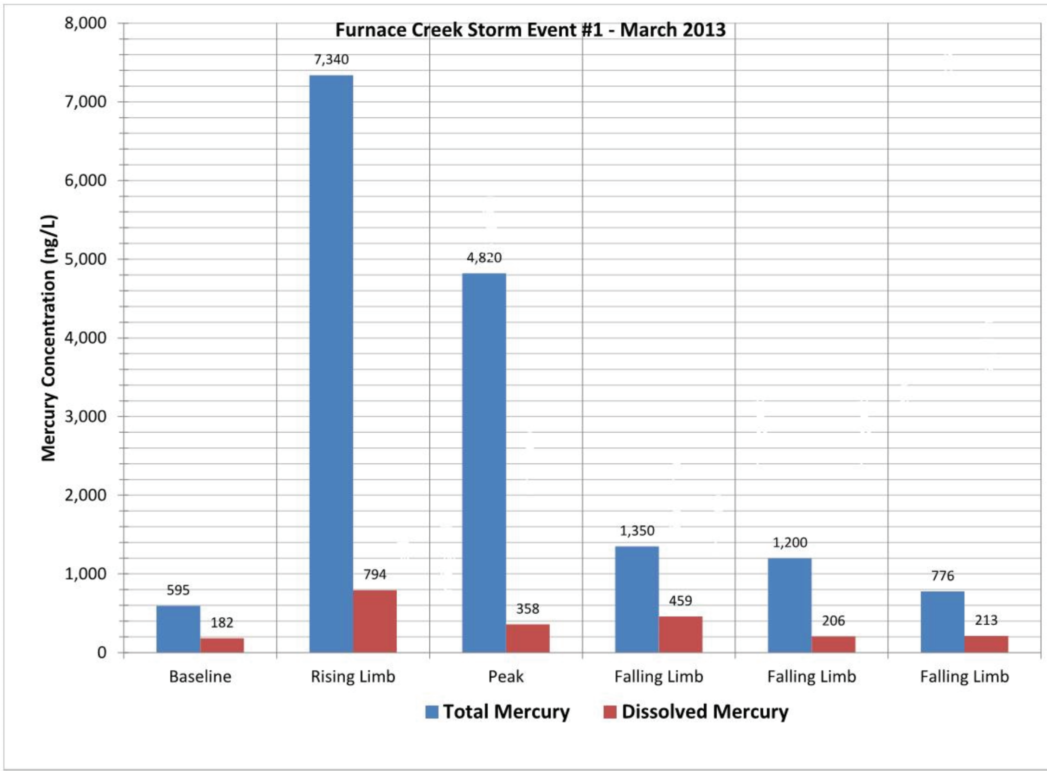

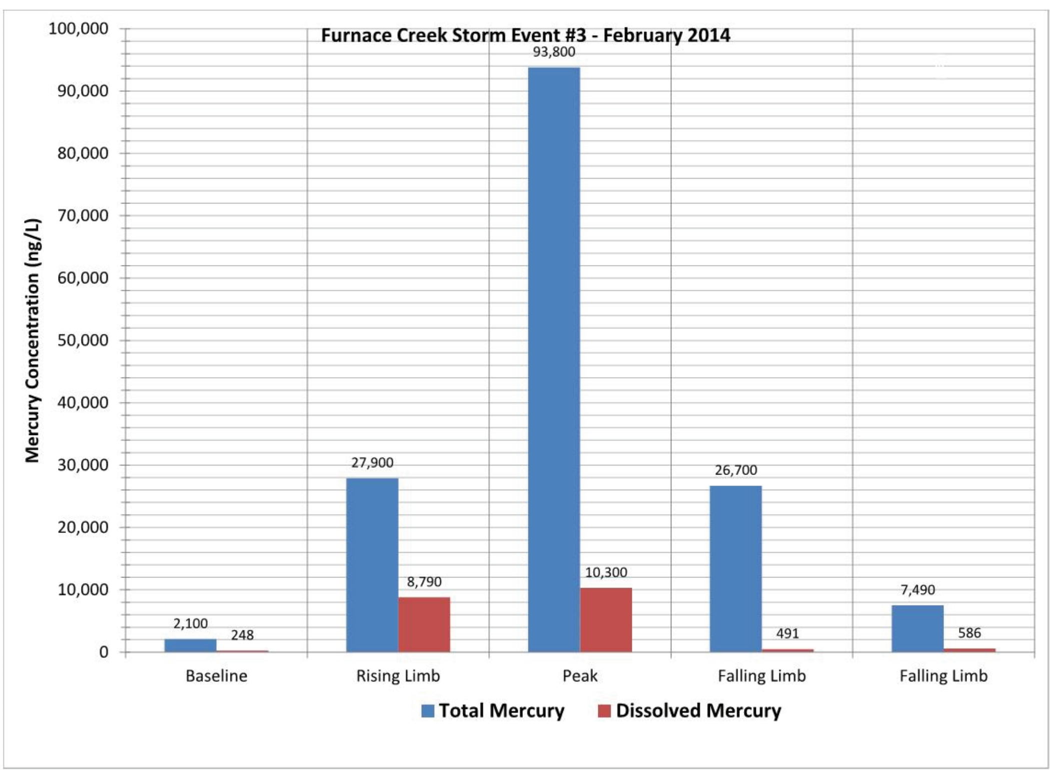

Notes:
ng/L – nanograms per liter
Samples collected at Furnace Creek station F1

EA CDM Smith

Black Butte Mine Superfund Site

Figure 2-4
Total Versus Dissolved Mercury in Surface Water at Furnace Creek

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Figure 2-5

Groundwater Monitoring Well Locations and Dissolved Mercury Concentrations

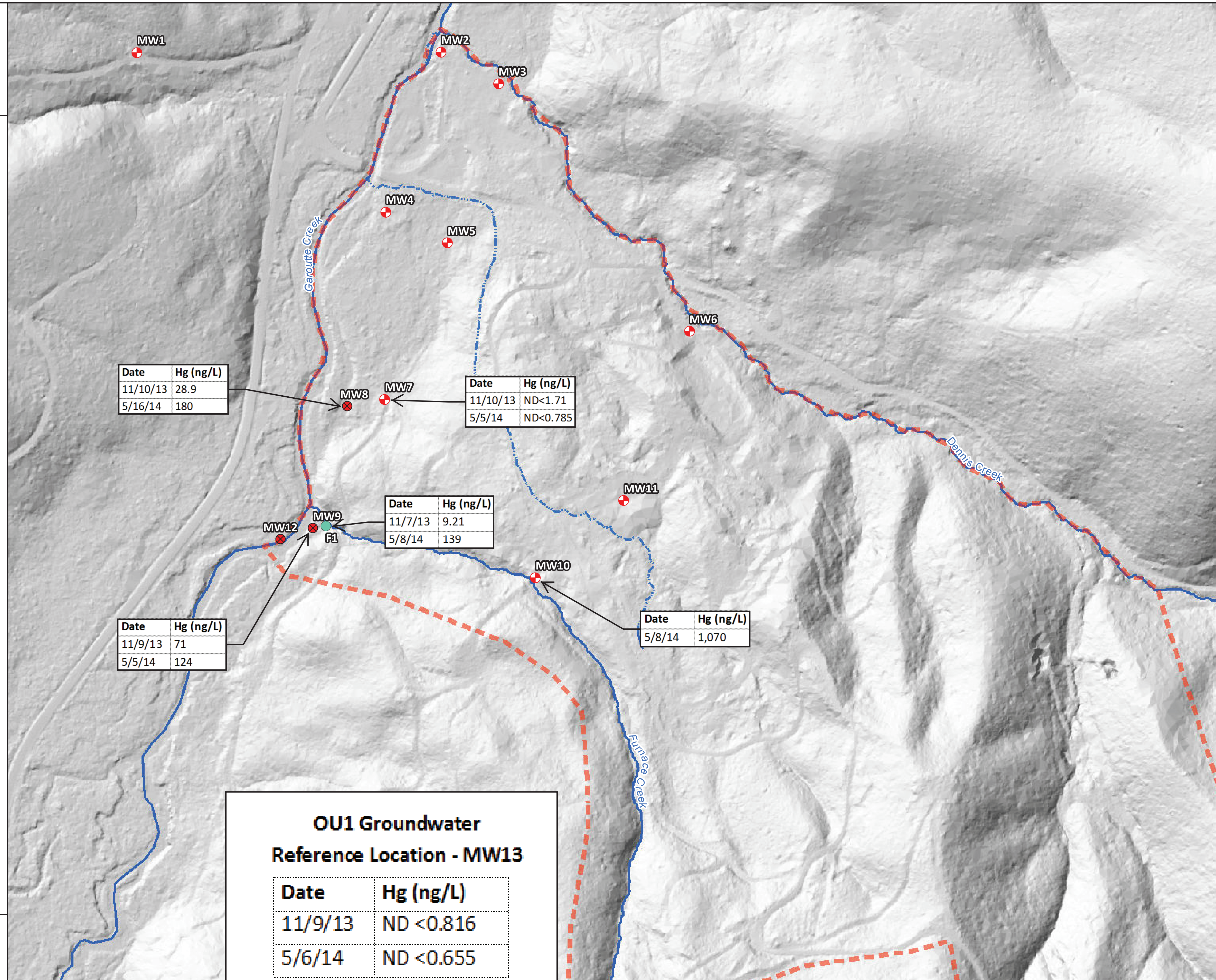
Legend

- Groundwater Monitoring Well (Sonic)
- Groundwater Monitoring Well (Hand Driven)
- Seepage Sample Point at the Buried Culvert
- Creek/Stream/Drainage
- Intermittent Creek/ Stream/Drainage
- OU1 Boundary

Notes:
ng/L = nanograms per liter
ND = not detected

N

0 500
Feet
1 inch = 300 feet



MW8:

Date	Hg (ng/L)
11/10/13	28.9
5/16/14	180

MW7:

Date	Hg (ng/L)
11/10/13	ND<1.71
5/5/14	ND<0.785

MW9:

Date	Hg (ng/L)
11/7/13	9.21
5/8/14	139

MW12:

Date	Hg (ng/L)
11/9/13	71
5/5/14	124

MW10:

Date	Hg (ng/L)
5/8/14	1,070

OU1 Groundwater Reference Location - MW13

Date	Hg (ng/L)
11/9/13	ND <0.816
5/6/14	ND <0.655

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8/4/2015

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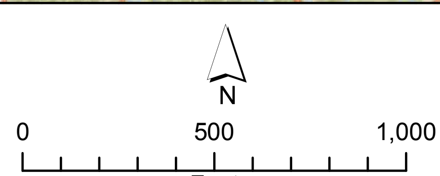
Figure 2-6

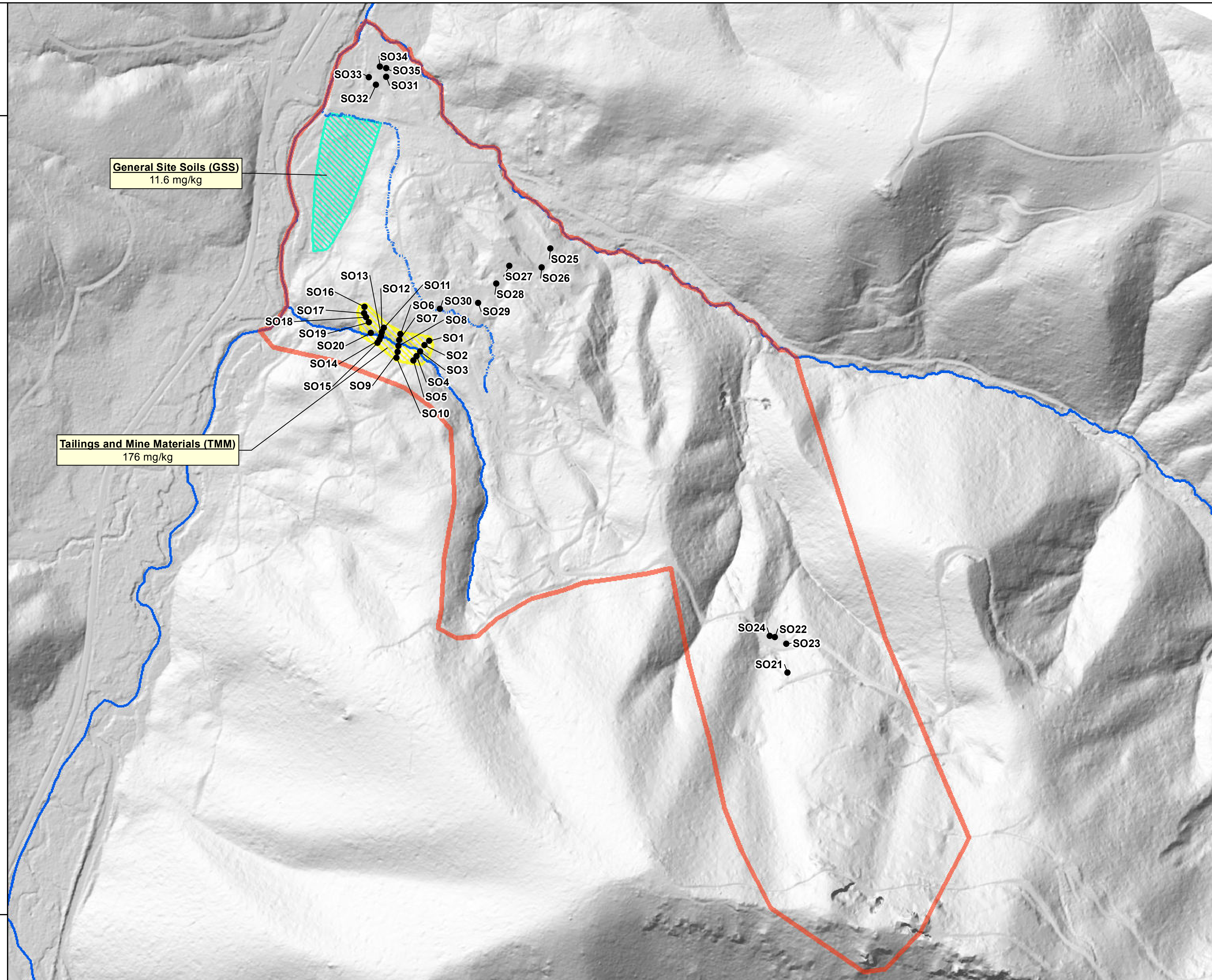
Incremental Soil Samples at OU1 and Average Mercury Concentrations in Soil

Legend

- Location of Discrete Point Samples
- Creek/Stream/Drainage
- Intermittent Creek/ Stream/Drainage
- General Site Soils Incremental Sampling Decision Unit
- Tailings and Mineralized Materials Incremental Sampling Decision Unit
- OU1 Boundary

Notes: mg/kg = milligrams per kilogram





EA CDM Smith

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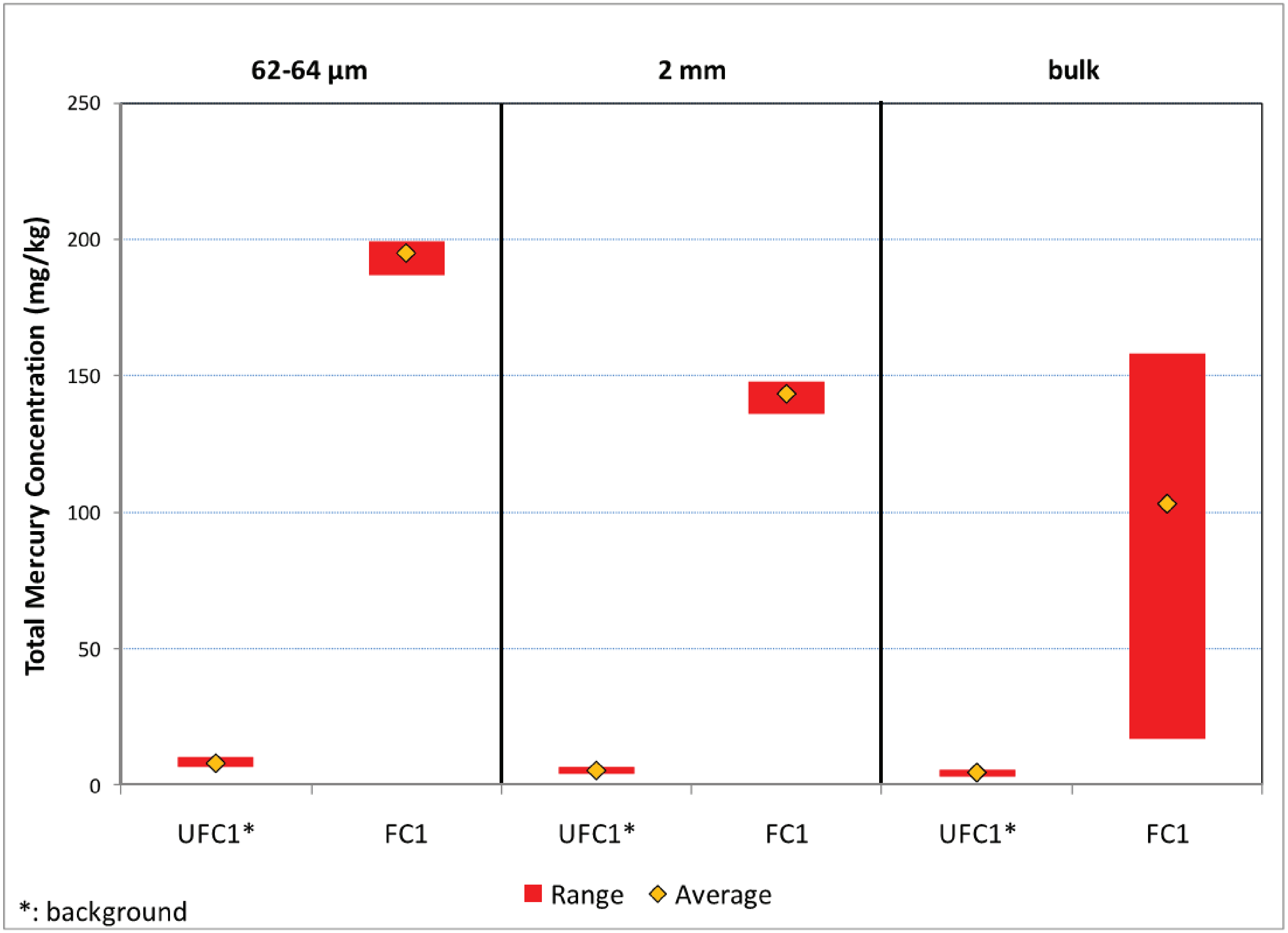

Notes:
mg/kg – milligrams per kilogram
µm – micron
Mm - millimeter
UFC1 – Incremental sediment sample collected from upstream Furnace Creek, upstream of the areas disturbed by the mining activities
FC1 – Incremental sediment sample collected from downstream Furnace Creek, just upstream of the Garoutte Creek confluence

EA CDM Smith

Black Butte Mine Superfund Site

Figure 2-7
Mercury Concentrations in Sediment at Upstream and Downstream Furnace Creek

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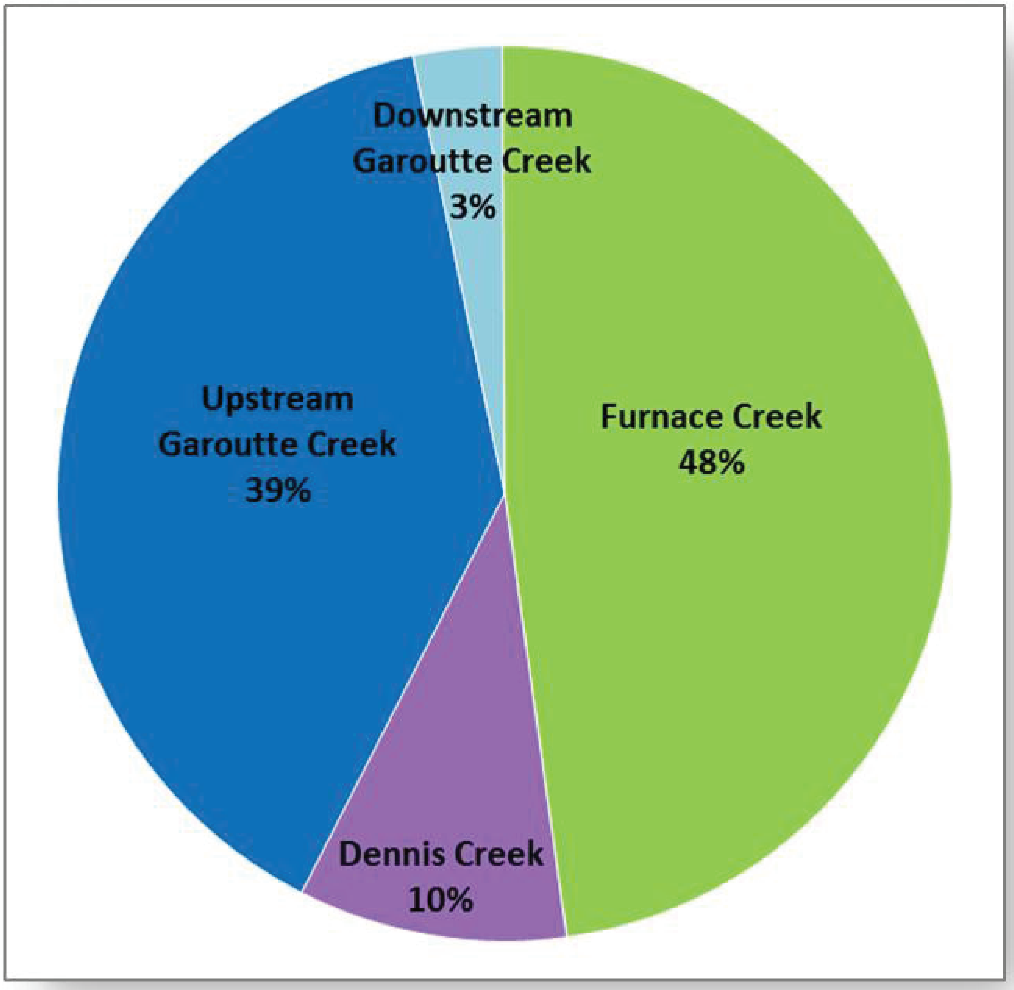

Based on data collected through
February 2014

EA CDM Smith	**Black Butte Mine Superfund Site**	**Figure 2-8** Percent Contribution to Annual Mercury Loads in Downstream Watershed

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Figure 3-1

Removal Action Area Boundary

Legend

- EPA Monitoring Well Soil Sample Locations (2013/2014 Data)
- EPA Soil Sample Locations (Feb 2014 Event)
- DEQ Soil Sample Locations (2003)
- Creek/Stream/Drainage
- Intermittent Creek/Stream/Drainage
- Location of Old Furnace Area Capped During the 2007 Removal Action
- Proposed Furnace Creek Removal Action Boundary
- OU1 Boundary
- Main Tailings Pile
- Furnace Creek Tailings Area
- Furnace Catchment Boundary

Soil Concentrations for All Samples

Mercury (mg/kg)

- ≤ 10
- >10 - 50
- >50 - 100
- >100 - 200
- >200

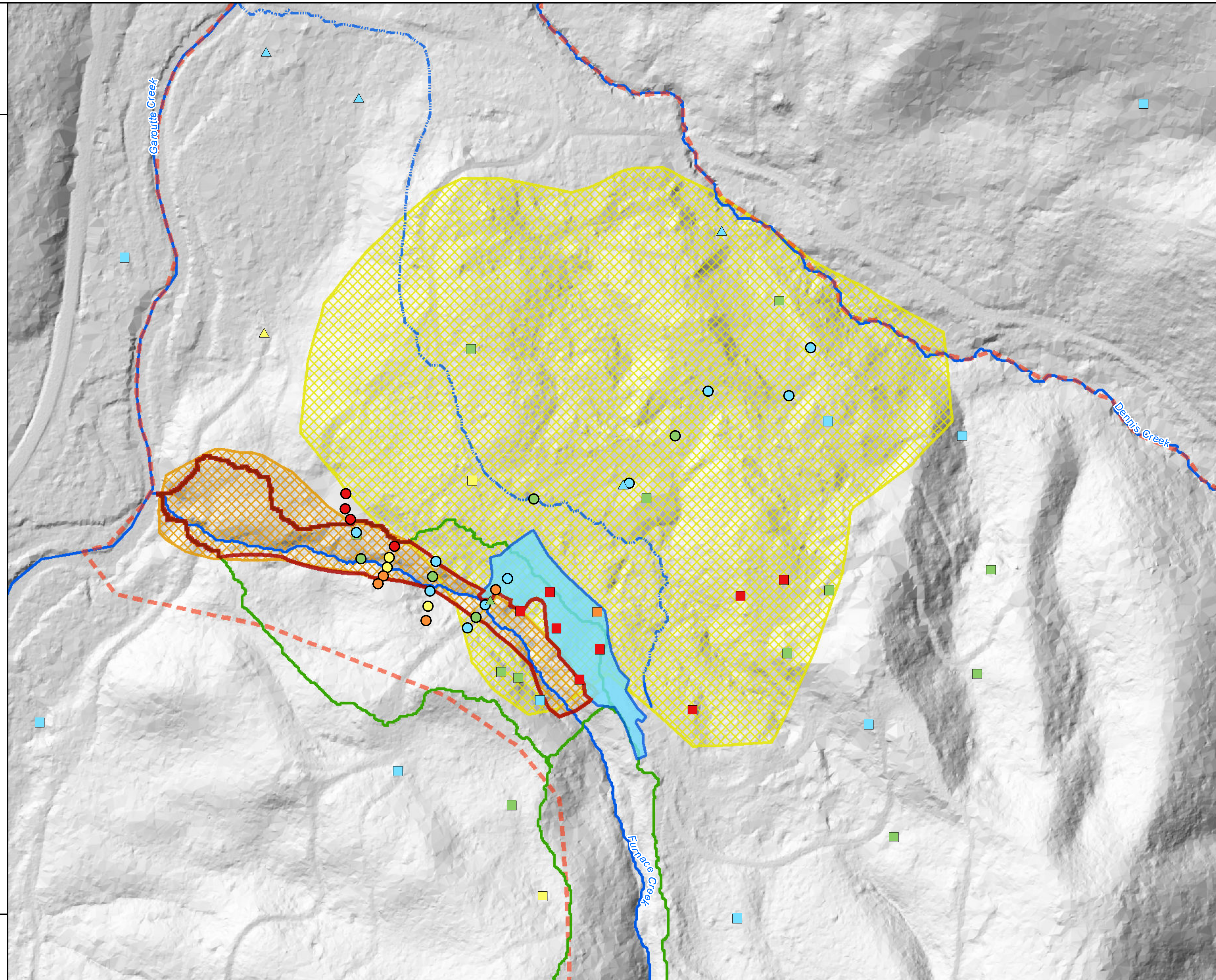
Note: 2003 DEQ soil sample locations within the footprint of the 2007 removal action capping are no longer exposed at the surface.

N

0 100 200 400

Feet

1 inch = 200 feet



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Tables

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Table 5-1
Identification of Data and Information Needs for Potential Removal Approaches Evaluated in EE/CA
Furnace Creek Area of OU1, Black Butte Mine Superfund Site

Removal Approaches	Technology	Process Option	Description of Option	Data and Information Needs	Site Specific Data Collection Complete?	Rationale for Collection of Site Specific Data	Risk in Proceeding with the EE/CA without Additional Data Collection
Particulate Management	Isolation/ Separation Measures	Water Diversion	Water diversion using engineered structures (e.g. pipes, lined channels) or through stream channel relocation would be used to limit or redirect surface water flowing to or contacting contaminated areas to minimize particulate mobilization.	▪ The lateral extent of contaminated solid media for siting water diversion structures	▪ No	▪ The lateral extent of tailings are not fully delineated within the Furnace Creek catchment area, particularly in the western half of the catchment. Mapping of the lateral extent of tailings in the field will provide information needed for determining the location extent of isolation/separation measures.	▪ If no additional data is collected of the lateral extent of tailings, the extent and cost of water diversion structures may be overestimated in the EE/CA.
				▪ Hydrology and hydraulics information for Furnace Creek and contributing watershed	▪ Yes	▪ Information is needed for sizing water diversion structures. Existing topography data from LiDAR data set and watershed model can be used.	▪ None
				▪ Geotechnical study for diversion structure construction	▪ No	▪ Information is needed to evaluate effectiveness or implementability of the process option. The main focus of the geotechnical data would be to evaluate the suitability and stability of soil for construction water diversion structures on the slopes and drainage within the Furnace Creek catchment. A few representative samples of each material (surface tailings, mercury-impacted soils, and borrow soil) would need to be collected for geotechnical analysis.	▪ Use of assumptions on geotechnical parameters in the EE/CA, rather than site-specific data introduces uncertainty in determining effectiveness and/or implementability of constructing water diversion structures.
		Detention Basins/ Impoundm ents	Basins or impoundments would be constructed to detain surface water before discharge away from contaminated areas using water diversions to slow water velocity and limit further erosion downgradient.	▪ The lateral extent of contaminated solid media for determining the location and sizing of detention basins /impoundments	▪ No	▪ The lateral extent of tailings are not fully delineated within the Furnace Creek catchment area, particularly in the western half of the catchment. Mapping of the lateral extent of tailings in the field will provide information needed for determining the location and sizing of detention basins/ impoundments.	▪ If no addition data is collected of the lateral extent of tailings, the size and cost of the detention basins/impoundments may be overestimated in the EE/CA.

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Table 5-1 (continued)
Identification of Data and Information Needs for Potential Removal Approaches Evaluated in EE/CA
Furnace Creek Area of OU1, Black Butte Mine Superfund Site

Removal Approaches	Technology	Process Option	Description of Option	Data and Information Needs	Site Specific Data Collection Complete?	Rationale for Collection of Site Specific Data	Risk in Proceeding with the EE/CA without Additional Data Collection
Particulate Management (cont.)				▪ Hydrology and watershed study of the Furnace Creek catchment to determine sizing of detention/sedimentation basins o Geographic location of the point at which peak flow must be computed. o Location of the boundaries of the watershed from which runoff contributes to flow at the point of interest. ▪ Properties of the watershed within those boundaries (area, slope, shape, and topography)	▪ Yes	▪ Information is needed for siting and sizing detention basins/impoundments. Existing topography data from LiDAR data set and watershed model can be used. Information is a critical need for evaluation of effectiveness or implementability. ▪ Geographic location of the point at which peak flow must be computed will be determined using data from the existing watershed model during the EE/CA.	▪ None
				▪ Description of the drainage features of the watershed.			
				▪ Climate data, rainfall observations and statistics of the precipitation.			
				▪ Stream discharge observations and statistics on discharge.			
				▪ Suspended sediment concentrations and particle size.			

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Table 5-1 (continued)
Identification of Data and Information Needs for Potential Removal Approaches Evaluated in EE/CA
Furnace Creek Area of OU1, Black Butte Mine Superfund Site

Removal Approaches	Technology	Process Option	Description of Option	Data and Information Needs	Site Specific Data Collection Complete?	Rationale for Collection of Site Specific Data	Risk in Proceeding with the EE/CA without Additional Data Collection
Particulate Management (cont.)				▪ Geotechnical data for isolation/ separation or retention measures: o Soil type and particle size analysis o Infiltration rate for basin/ impoundments	▪ No	▪ Information is needed to evaluate effectiveness or implementability of the process option. The main focus of the geotechnical data would be to evaluate the suitability and stability of soil for construction of detention basins/impoundments and determine infiltration rates. A few representative samples of each material present at the planned construction site would need to be collected for geotechnical analysis.	▪ Use of assumptions on geotechnical parameters in the EE/CA, rather than site-specific data introduce uncertainty in determining effectiveness and/or implementability of detention basin/impoundments. The sizing and cost may be underestimated or overestimated if site-specific infiltration rates are different than assumed.
	Retention Measures	Settling or Sedimentation Basins/ Impoundments	Basins or impoundments with or without drop inlet structures would be used to temporarily retain stormwater from contaminated areas to capture sediments and retain them for further management using other approaches to minimize particulate mobilization in stormwater before discharge away from contaminated areas.	▪ Same data and information needs as detention basins/ impoundments			
Containment	Surface Source Controls (Covers)	Grading/ Revegetation	Contaminated solid media would be contoured to promote drainage and would be planted with native vegetation.	▪ Lateral extent of contaminated solid media with particulates containing mercury (i.e. tailings, soil, and sediment) to determine extent of grading/ revegetation required	▪ No	▪ The lateral extent of tailings are not fully delineated within the Furnace Creek catchment area, particularly in the western half of the catchment. Field mapping of the lateral extent of tailings will provide information needed to determine the extent and location where grading and vegetation is needed.	▪ The extent of tailings and required extent of grading and revegetation may be overestimated if additional field delineation is not completed. This may result overestimation of the cost and implementability of this process option in the EE/CA.
				▪ Topographic evaluation to determine grading equipment access limitations. accessibility	▪ Yes	▪ The evaluation of grading equipment limitations is critical in determining implementability and cost. Existing LiDAR data set can be used to evaluate slopes and equipment access limitations.	▪ None
				▪ Geotechnical data, including soil type, particle size, and slope stability analysis, to evaluate grading measures	▪ No	▪ Information is needed to evaluate effectiveness or implementability of the process option. The main focus of the geotechnical data would be to evaluate the suitability and stability of soil for grading and revegetation. A few representative samples of each material (surface tailings, mercury-impacted soils, and borrow soil) would need to be collected for geotechnical analysis. Slope stability calculations would be performed.	▪ Use of assumptions of geotechnical parameters in the EE/CA, rather than site-specific data introduce uncertainty in determining effectiveness and/or implementability of grading and revegetating the removal action area.

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Table 5-1 (continued)
Identification of Data and Information Needs for Potential Removal Approaches Evaluated in EE/CA
Furnace Creek Area of OU1, Black Butte Mine Superfund Site

Removal Approaches	Technology	Process Option	Description of Option	Data and Information Needs	Site Specific Data Collection Complete?	Rationale for Collection of Site Specific Data	Risk in Proceeding with the EE/CA without Additional Data Collection
Containment (Cont.)				▪ Regulatory requirements for vegetation selection	▪ No	▪ Information is needed to determine restrictions on vegetation to include in process option.	▪ Assumptions of the regulatory requirements may add uncertainty to the implementability and cost during the EE/CA.
		Exposure Barrier	Contaminated solid media would be covered with a layer of borrow soil or rock to prevent direct exposure to mercury and reduction of erosion to surface water. However exposure barrier would have minimal reductions of leaching to groundwater.	▪ Lateral extent of contaminated solid media with particulates containing mercury (i.e. tailings, soil, and sediment) to determine extent of covers required	▪ Same data and information needs as grading/revegetation		
				▪ Geotechnical data, including soil type, particle size analysis, permeability and hydraulic conductivity, slope stability analysis, to evaluate containment measures	▪ No	▪ Information is needed to evaluate effectiveness or implementability of the process option. The main focus of the geotechnical data would be to evaluate the suitability and stability of soil for placing borrow soil or rock on the slopes of the Furnace Creek catchment. A few representative samples of each material (surface tailings, mercury-impacted soils, and borrow soil) would need to be collected for geotechnical analysis. Slope stability calculations would be performed.	▪ Use of assumptions on geotechnical parameters in the EE/CA, rather than site-specific data introduce uncertainty in determining effectiveness and/or implementability of constructing a soil or rock cover over the removal action area.
				▪ Location, suitability, and availability of potential onsite and offsite borrow areas and quarries	▪ No	▪ Identifying a location onsite or offsite borrow areas or quarries is necessary to evaluate the implementability and cost of this process option. Soil samples should be collected and analyzed in a laboratory to determine if geotechnical and chemical properties of the borrow material is suitable for constructing the exposure barrier.	▪ Use of assumptions on the availability of suitable borrow material may introduce uncertainty in the evaluation of implementability and cost in the EE/CA.
				▪ Location, suitability, and availability of potential commercial clean soil and rock sources	▪ No	▪ Identifying a location of a commercial source of clean soil and rock is necessary to evaluate the implementability and cost (material cost and transport cost) of this process option. Soil samples should be collected and analyzed in a laboratory to determine if geotechnical and chemical properties of the material is suitable for constructing the exposure barrier.	▪ Use of assumptions on the availability of suitable borrow material may introduce uncertainty in the evaluation of implementability and cost in the EE/CA.
				▪ Performance data and industry standards necessary to determine effectiveness of exposure barriers like simple soil cover	▪ Yes	▪ Information is need to determine the effectiveness of exposure barriers. Information from the 2007 TCRA can be used to evaluate effectiveness of a simple soil cover.	▪ None

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Table 5-1 (continued)
Identification of Data and Information Needs for Potential Removal Approaches Evaluated in EE/CA
Furnace Creek Area of OU1, Black Butte Mine Superfund Site

Removal Approaches	Technology	Process Option	Description of Option	Data and Information Needs	Site Specific Data Collection Complete?	Rationale for Collection of Site Specific Data	Risk in Proceeding with the EE/CA without Additional Data Collection
Removal, Transport Disposal	Removal	Mechanical Excavation	Contaminated solid media would be excavated using mechanical methods.	▪ Horizontal and vertical extent of contaminated solid media with particulates containing mercury (i.e. tailings, soil, and sediment) to determine the types of excavation methods required and volume of excavation	▪ No	▪ The horizontal and vertical extent of tailings are not fully delineated within the Furnace Creek catchment area, particularly in the western half of the catchment. Mapping of the lateral extent of tailings in the field will provide information needed to determine the volume of material that would require excavation. This information is needed to evaluate implementability and cost of mechanical excavation.	▪ The volume of tailings may be overestimated if additional field data collection is not completed. This may result in overestimation of the cost and implementability of the mechanical excavation process option in the EE/CA.
				▪ Geotechnical evaluation of slopes and topography affecting waste stability during excavation	▪ No	▪ An evaluation of the excavation depths, slopes, and soil properties is needed to assess stability of the excavations. This information is needed to determine excavation methods and equipment, which will affect the implementability and cost. A few representative samples of each material (surface tailings, mercury-impacted soils, and borrow soil) would need to be collected for geotechnical analysis and a slope stability analysis would need to be performed.	▪ Use of assumptions of geotechnical parameters in the EE/CA, rather than site-specific data introduce uncertainty in determining the implementability and cost of excavation.
				▪ Topographic evaluation for selected excavation methods and access requirements	▪ Yes	▪ Topographic evaluation for excavation methods and access requirements is critical in determining implementability and cost. Existing LiDAR data set can be used to evaluate slopes and equipment access limitations.	▪ None
				▪ Evaluation of contaminated building remnants at the Old Furnace structure to determine health and safety requirements and material disposal requirements for excavation of potential high level furnace wastes around the Old Furnace structure.	▪ No	▪ Residual mercury furnace wastes in the area of the Old Furnace have the potential for high levels of mercury. Sampling of soil and building materials in the Old Furnace area is needed to determine worker health and safety requirements and waste disposal requirements. This information is needed to evaluate implementability and cost.	▪ If additional data collection is not completed, conservative assumptions will be needed in the EE/CA that may overestimate excavation implementability and cost.
		Pneumatic removal (Vacuum Pumping)	Contaminated solid media would be excavated using vacuum hoses, vacuum trucks, or other pneumatic conveyance system.	Same data and information needs as mechanical excavation			
				▪ Geotechnical data determining feasibility of pneumatic removal	▪ No	▪ Geotechnical data is needed to determine the implementability of pneumatic removal. A few representative samples of each material (surface tailings, mercury-impacted soils, and sediment) would need to be collected for particle size analysis, moisture content, and bulk density.	▪ If assumptions are used, rather than site specific geotechnical data, then uncertainties will be introduced in the implementability of pneumatic removal.

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Table 5-1 (continued)
Identification of Data and Information Needs for Potential Removal Approaches Evaluated in EE/CA
Furnace Creek Area of OU1, Black Butte Mine Superfund Site

Removal Approaches	Technology	Process Option	Description of Option	Data and Information Needs	Site Specific Data Collection Complete?	Rationale for Collection of Site Specific Data	Risk in Proceeding with the EE/CA without Additional Data Collection
Removal, Transport Disposal (cont.)	Transport	Mechanical Transport (Hauling/ Conveying)	Contaminated solid media would be transported by truck or other mechanical conveyance method to disposal site.	▪ Horizontal and vertical extent of contaminated solid media with particulates containing mercury (i.e. tailings, soil, and sediment) to determine volume needing transport	▪ No	▪ The horizontal and vertical extent of tailings are not fully delineated within the Furnace Creek catchment area, particularly in the western half of the catchment. Mapping of the extent of tailings in the field will provide information needed to determine the volume of material that would require excavation and transport. This information is needed to evaluate implementability and excavation and transport.	▪ The volume of tailings may be overestimated if additional field data collection is not completed. This may result in overestimation of the cost and implementability of mechanical transport in the EE/CA.
				▪ Topographic evaluation using the existing LiDAR data for determining topographic constraints affecting loading of transport equipment and selection of transport methods, and access.	▪ Yes	▪ Topographic evaluation for excavation methods and access requirements is critical in determining implementability and cost. Existing LiDAR data set can be used to evaluate slopes and equipment access limitations.	▪ None
				▪ Distance to disposal or treatment facility locations.	▪ No	▪ The location of the closest suitable offsite disposal or treatment facility would need to be determined. The distance of the disposal or treatment facility from the site will affect the implementability and cost of mechanical transport.	▪ None
				▪ Regulatory requirements for transporting mine materials and soils.	▪ No	▪ Information is needed to determine restrictions on truck or rail transport from the site.	▪ Assumptions on the regulatory requirements may add uncertainty to the implementability and cost during the EE/CA.
		Hydraulic Transport (Slurry Pumping)	Contaminated solid media would be mixed with water and be piped in slurry form to disposal site.	▪ Same data and information needs as mechanical excavation			
				▪ Regulatory requirements for transporting mine materials and soils in a slurry form or using vacuum system.	▪ No	▪ Information is needed to determine restrictions on transport of waste in a slurry form from the site.	▪ Assumptions on the regulatory requirements may add uncertainty to the implementability and cost evaluation during the EE/CA.
		Pneumatic Transport (Vacuum Pumping)	Contaminated solid media would be piped using a vacuum system to disposal site.	▪ Same data and information needs as hydraulic transport			

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Table 5-1 (continued)
Identification of Data and Information Needs for Potential Removal Approaches Evaluated in EE/CA
Furnace Creek Area of OU1, Black Butte Mine Superfund Site

Removal Approaches	Technology	Process Option	Description of Option	Data and Information Needs	Site Specific Data Collection Complete?	Rationale for Collection of Site Specific Data	Risk in Proceeding with the EE/CA without Additional Data Collection
Removal, Transport Disposal (cont.)	Disposal	Onsite Disposal	Contaminated solid media would be disposed of onsite in a repository.	▪ Horizontal and vertical extent of contaminated solid media with particulates containing mercury (i.e. tailings, soil, and sediment) to determine capacity of onsite disposal unit.	▪ No	▪ The horizontal and vertical extent of tailings are not fully delineated within the Furnace Creek catchment area, particularly in the western half of the catchment. Mapping of the extent of tailings in the field will provide information needed to determine the sizing of an onsite repository. This information is critical in evaluating the implementability and cost of onsite disposal.	▪ The volume of tailings may be overestimated if additional field data collection is not completed. This may result in overestimation of the cost and implementability of construction of an onsite repository in the EE/CA.
				▪ Location and suitability of potential disposal locations based on topography, geology, accessibility, and land ownership.	▪ Yes	▪ Existing data collected during the OU1 RI will be reviewed to determine a suitable location of on onsite repository.	▪ None
				▪ Geotechnical data, including soil type, particle size analysis, moisture content, bulk density, and slope stability analysis, evaluating onsite disposal	▪ No	▪ The main focus of the geotechnical data would be to evaluate stability of disposal repository site and soil covers. A few representative samples of each material (surface tailings, mercury-impacted soils, and borrow soil) would need to be collected for geotechnical analysis and a slope stability analysis performed.	▪ If assumptions are used, rather than site specific geotechnical data, then uncertainties will be introduced in the implementability of an onsite repository.
				▪ Regulatory requirements for onsite disposal	▪ No	▪ Information is needed to determine restrictions on construction of an onsite waste repository.	▪ Assumptions on the regulatory requirements may add uncertainty to the implementability and cost during the EE/CA.
				▪ Data and information need described under Containment for determining a source for the onsite disposal repository cap and regulatory requirements for cover thickness.	▪ Same data and information needs as hydraulic transport		

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Appendix A

XRF and Lumex Mercury Results for Soil from the 2007 Removal Action

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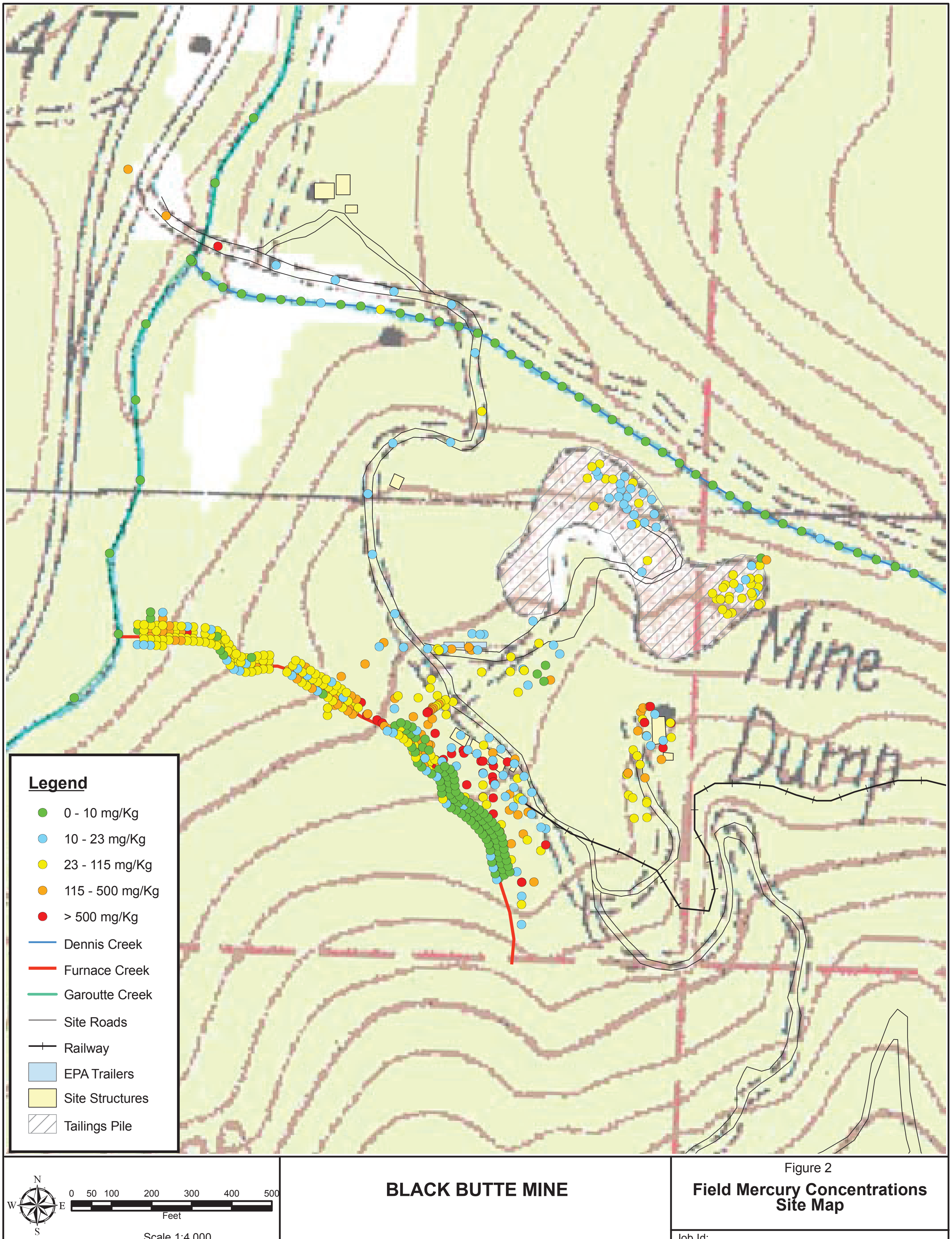

BLACK BUTTE MINE

Lane County, Oregon

Figure 2

Field Mercury Concentrations Site Map

ecology and environment, inc.
International Specialists in the Environment
Portland, Oregon

Job Id: 002233.0026.01IA	
Date: 10/15/2007	GIS Analyst: avh
Map Source Information: USGS Topographic Map. Harness Mountain, Oregon. Scale 1-24,000 .	

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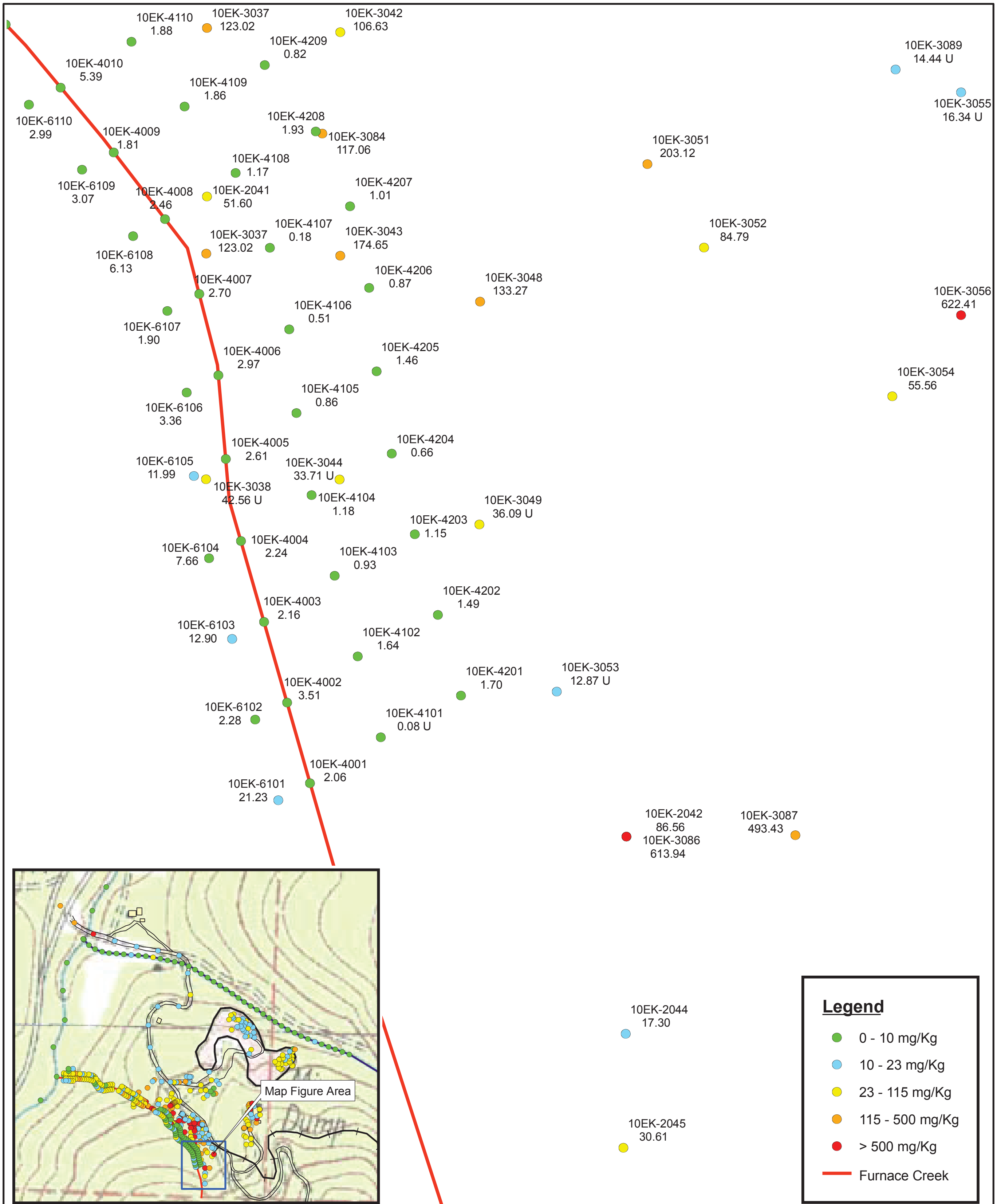

N
W E
S

0 5 10 20 30

Feet

Scale 1:300

ecology and environment, inc.
International Specialists in the Environment
Portland, Oregon

BLACK BUTTE MINE

Lane County, Oregon

Figure 2C

Field Mercury Concentrations
Furnace Creek Section 1
(East End)

Job Id: 002233.0026.01IA	
Date: 10/15/2007	GIS Analyst: avh
Map Source Information: USGS Topographic Map. Harness Mountain, Oregon. Scale 1-24,000 .	

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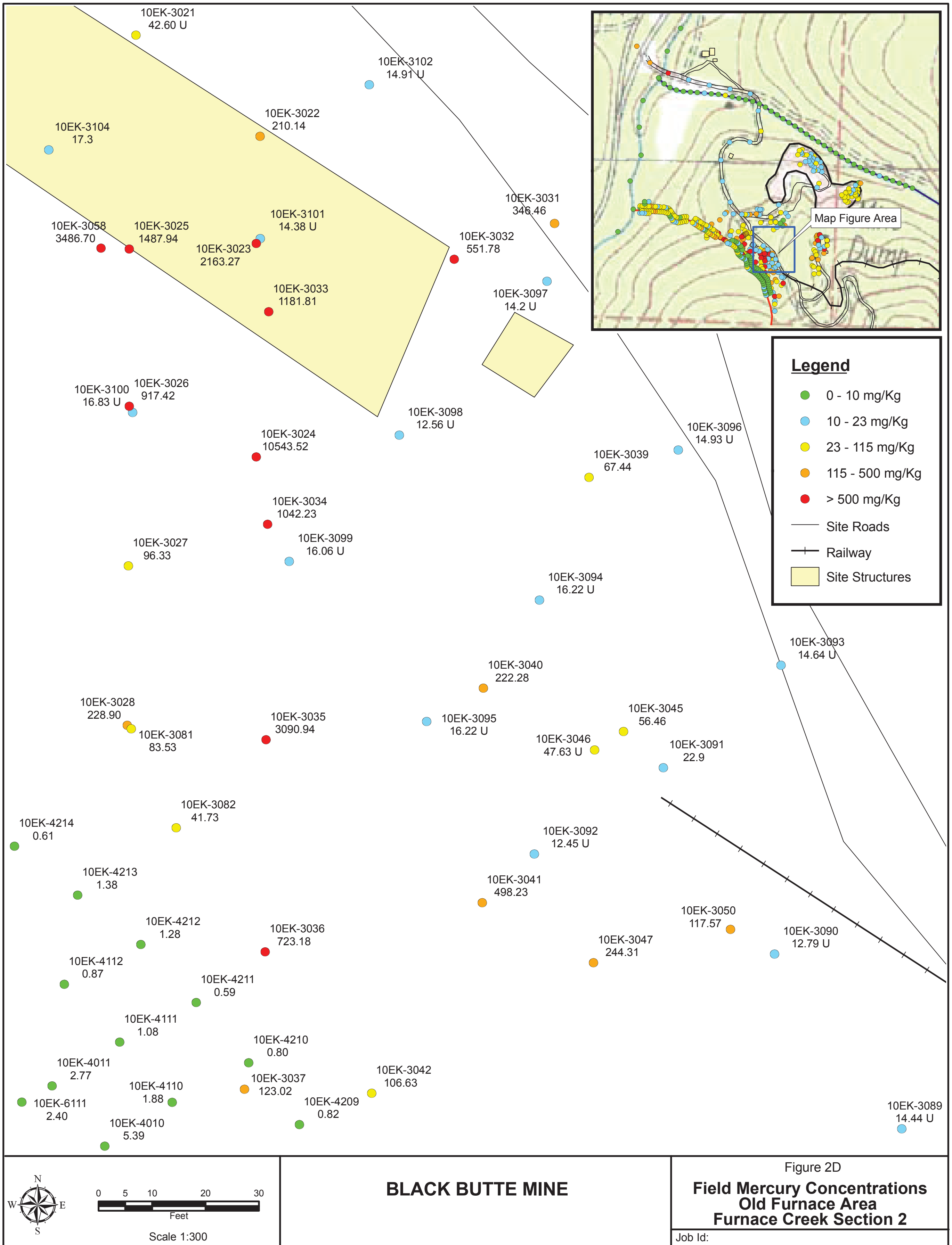

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Portland, Oregon

BLACK BUTTE MINE

Lane County, Oregon

Figure 2D

Field Mercury Concentrations
Old Furnace Area
Furnace Creek Section 2

Job Id:
002233.0026.01IA

Date:
10/15/2007

GIS Analyst:
avh

Map Source Information: USGS Topographic Map.
Harness Mountain, Oregon. Scale 1-24,000 .

\EDMS-Projects\Black Butte Mine\removal_aug07\figure 1d.mxd

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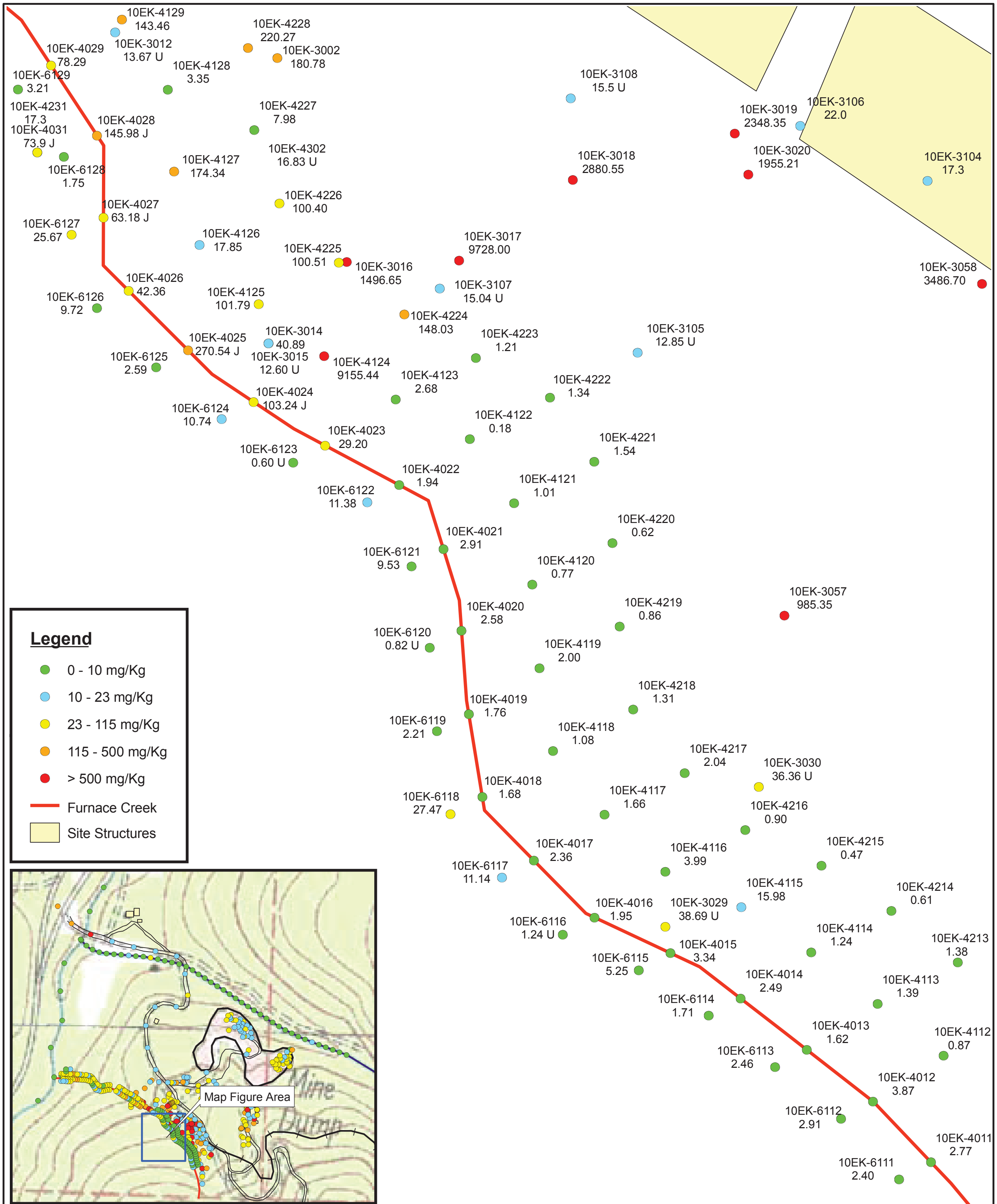

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Portland, Oregon

BLACK BUTTE MINE

Lane County, Oregon

Figure 2E
Field Mercury Concentrations Furnace Creek Section 3

Job Id:
002233.0026.01IA

Date:
10/15/2007

GIS Analyst:
avh

Map Source Information: USGS Topographic Map.
Harness Mountain, Oregon. Scale 1-24,000 .

\EDMS-Projects\Black Butte Mine\removal_aug07\figure 1e.mxd

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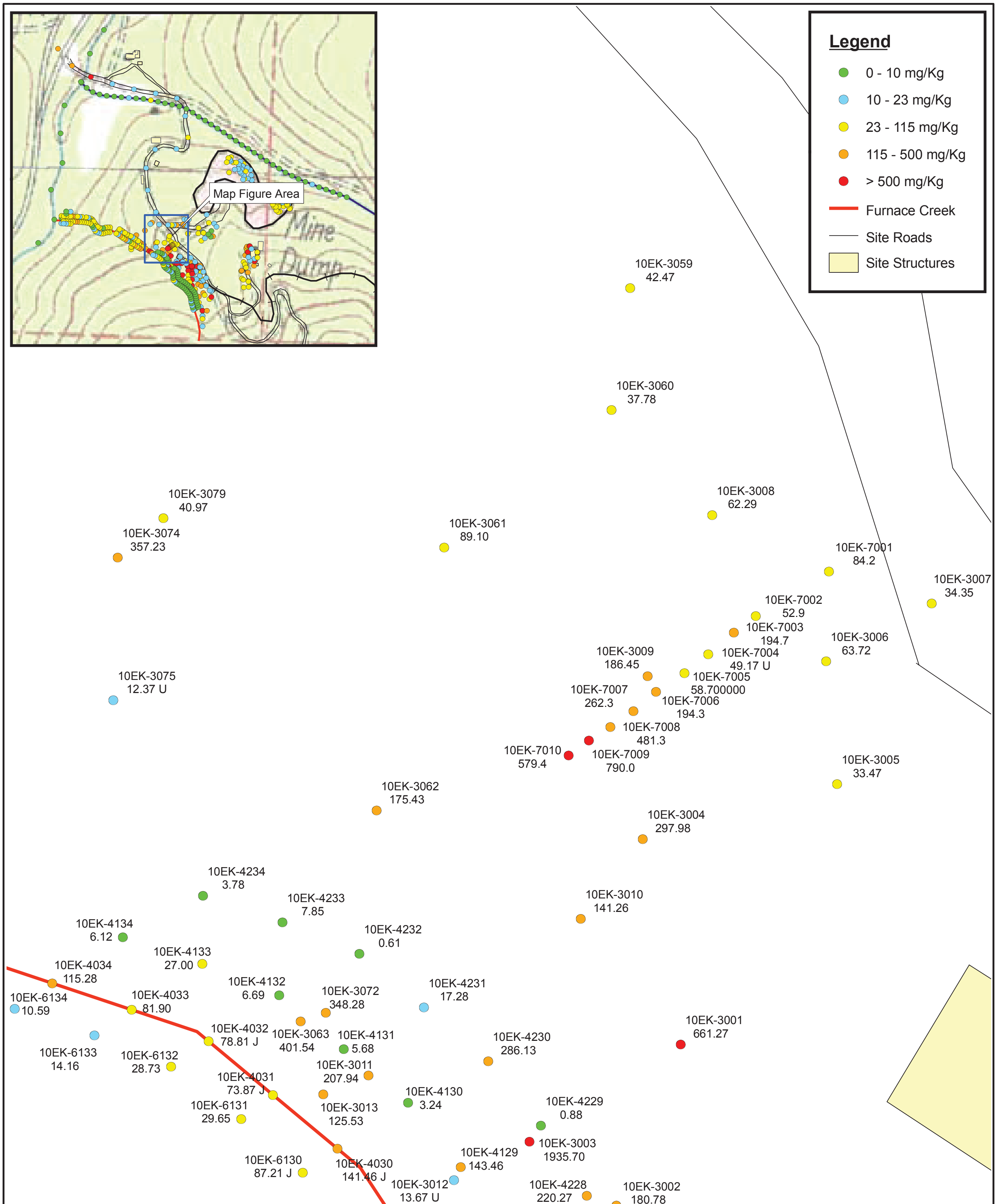

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BLACK BUTTE MINE

Lane County, Oregon

Figure 2F

Field Mercury Concentrations Furnace Creek Section 4

Job Id:
002233.0026.01IA

Date:	GIS Analyst:
10/15/2007	avh

Map Source Information: USGS Topographic Map. Harness Mountain, Oregon. Scale 1-24,000 .

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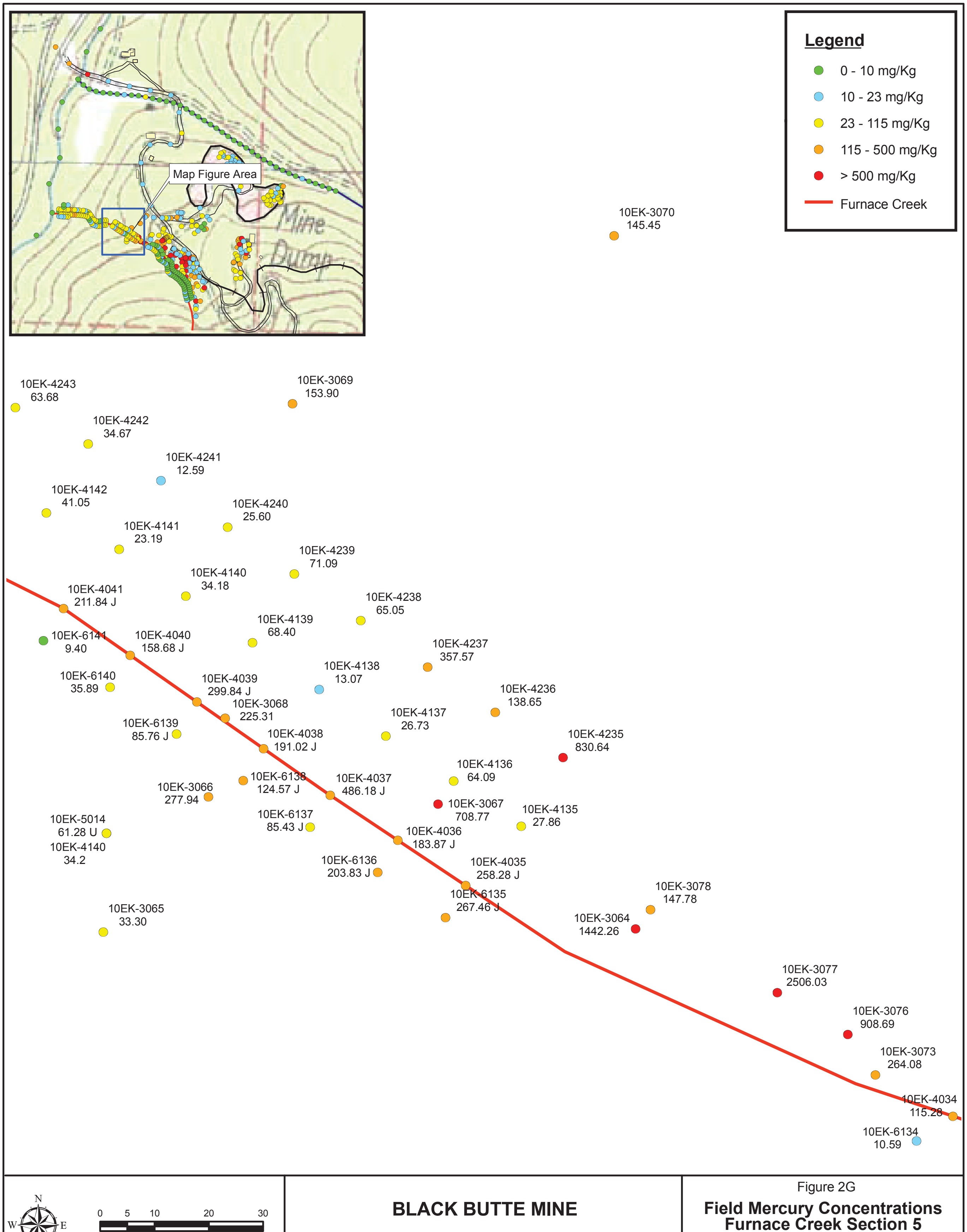

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BLACK BUTTE MINE

Lane County, Oregon

Figure 2G

Field Mercury Concentrations
Furnace Creek Section 5

Job Id: 002233.0026.01IA

Date: 10/15/2007

GIS Analyst: avh

Map Source Information: USGS Topographic Map. Harness Mountain, Oregon. Scale 1-24,000 .

\EDMS-Projects\Black Butte Mine\removal_aug07\figure 1g.mxd

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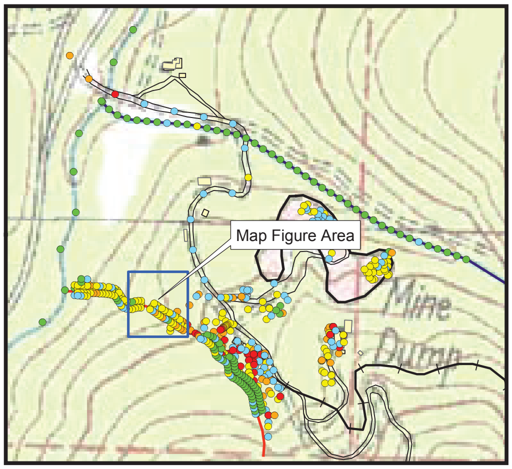
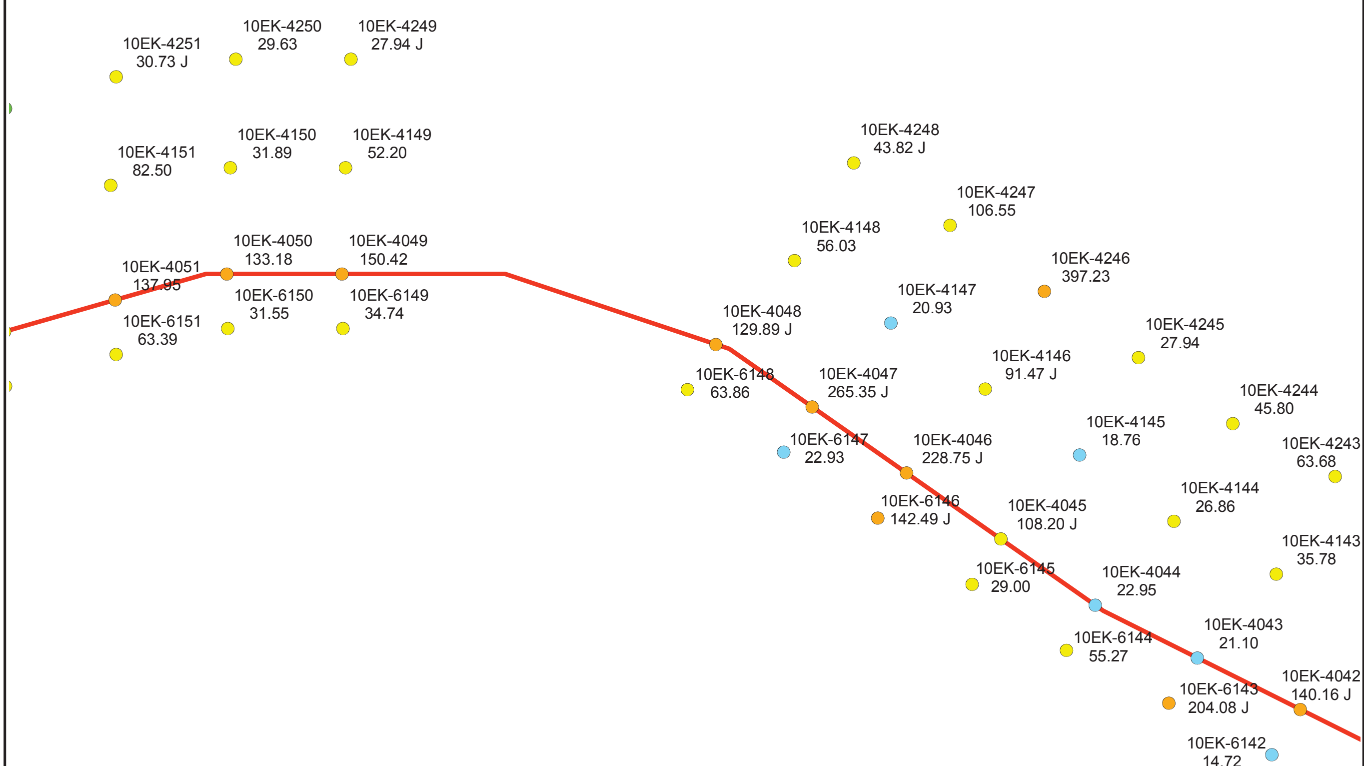


Legend

- 0 - 10 mg/Kg
- 10 - 23 mg/Kg
- 23 - 115 mg/Kg
- 115 - 500 mg/Kg
- > 500 mg/Kg
- Furnace Creek



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BLACK BUTTE MINE

Lane County, Oregon

Figure 2H

Field Mercury Concentrations Furnace Creek Section 6

Job Id:
002233.0026.01IA

Date:
10/15/2007

GIS Analyst:
avh

Map Source Information: USGS Topographic Map. Harness Mountain, Oregon. Scale 1-24,000 .

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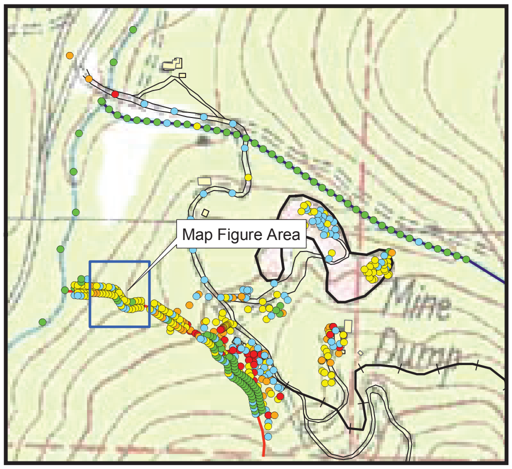
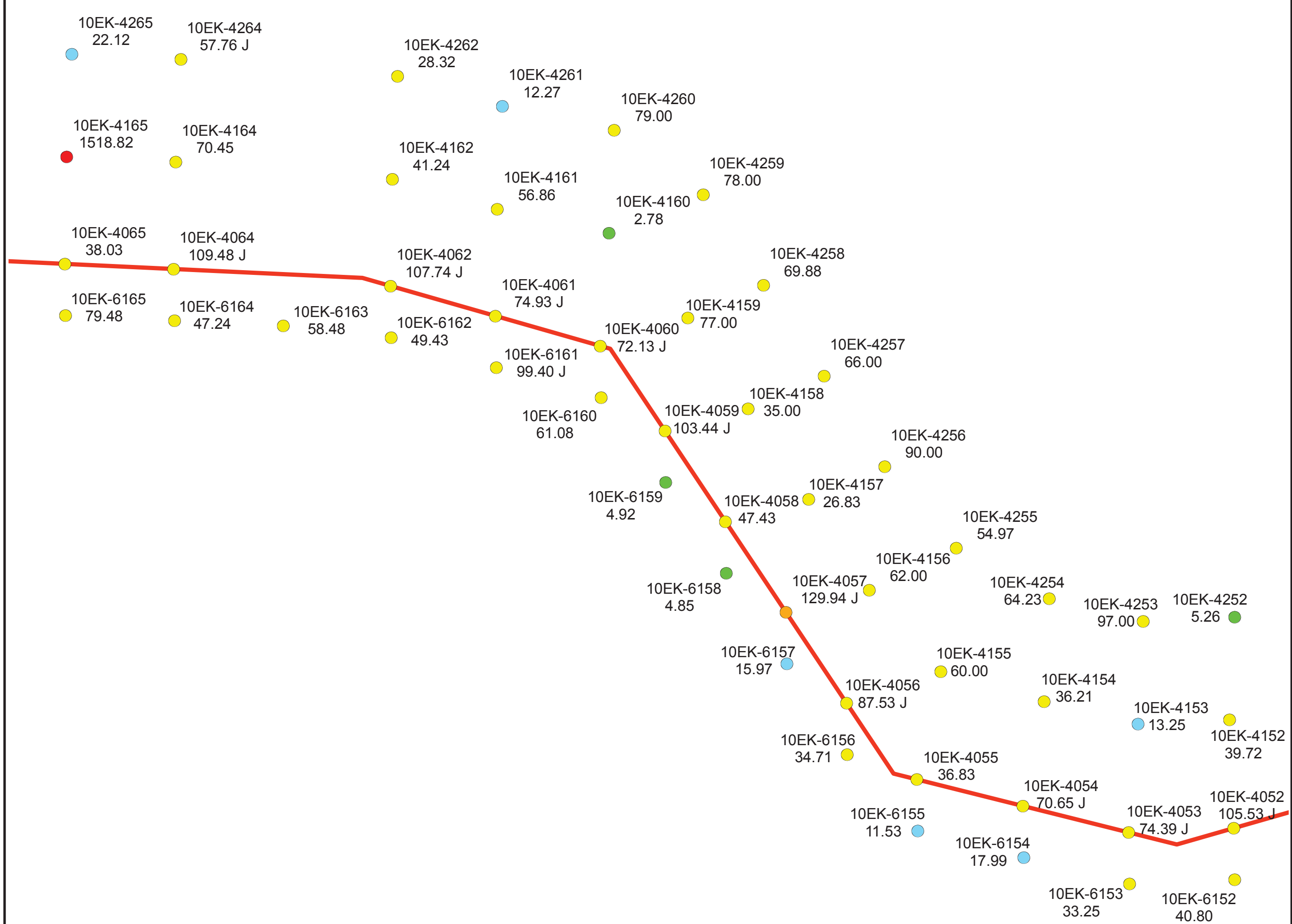


Legend

- 0 - 10 mg/Kg
- 10 - 23 mg/Kg
- 23 - 115 mg/Kg
- 115 - 500 mg/Kg
- > 500 mg/Kg
- Furnace Creek



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Scale 1:300

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BLACK BUTTE MINE

Lane County, Oregon

Figure 2I

Field Mercury Concentrations Furnace Creek Section 7

Job Id: 002233.0026.01IA

Date: 10/15/2007

GIS Analyst: avh

Map Source Information: USGS Topographic Map. Harness Mountain, Oregon. Scale 1-24,000 .

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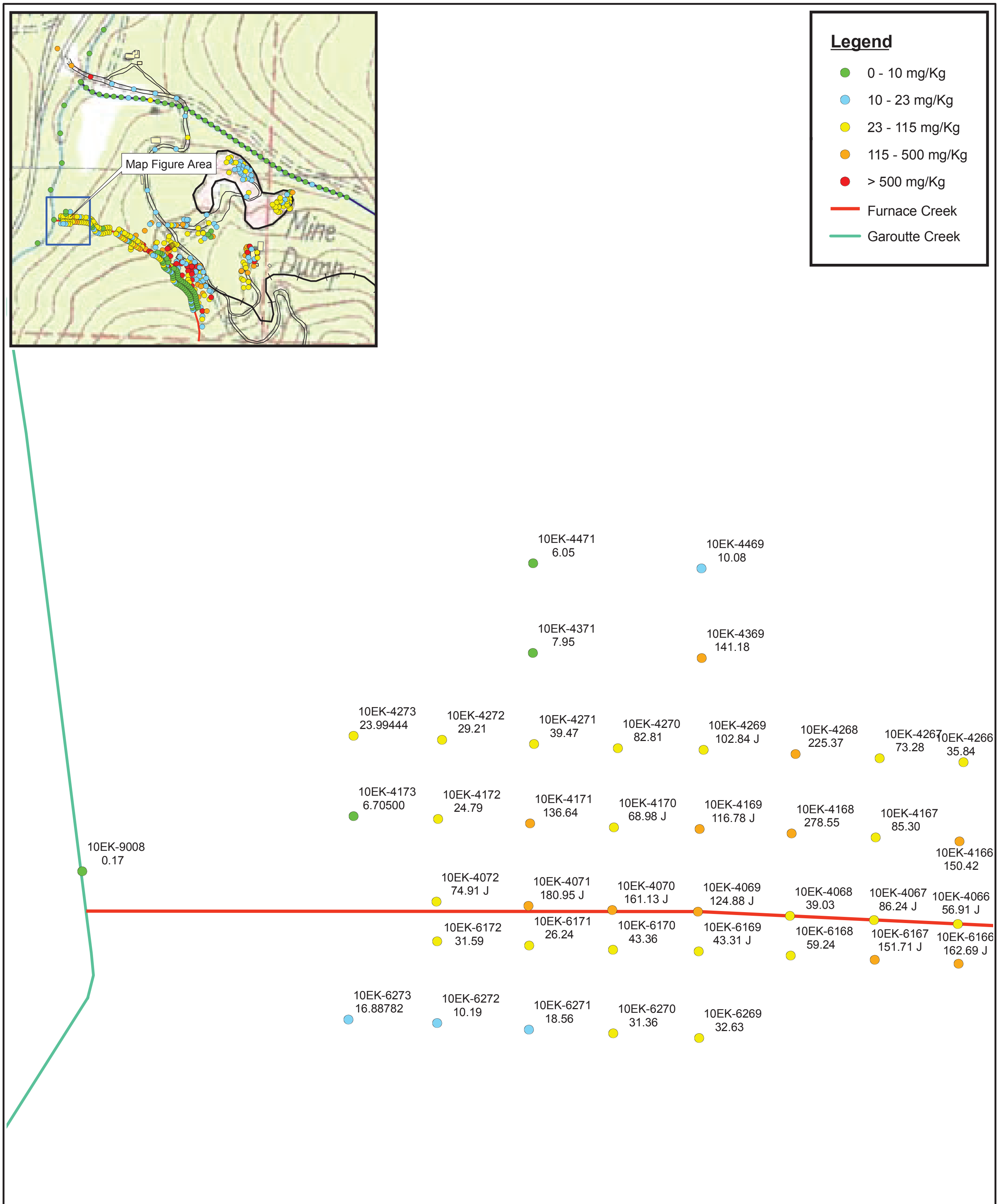

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Scale 1:300

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Portland, Oregon

BLACK BUTTE MINE

Lane County, Oregon

Figure 2J

Field Mercury Concentrations Furnace Creek Section 8 (West End)

Job Id:
002233.0026.01IA

Date:
10/15/2007

GIS Analyst:
avh

Map Source Information: USGS Topographic Map. Harness Mountain, Oregon. Scale 1-24,000 .

\EDMS-Projects\Black Butte Mine\removal_aug07\figure 1j.mxd

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Table I-2
TOTAL MERCURY IN SAMPLES FROM OLD ORE FURNACE AREA
BLACK BUTTE MINE
LANE COUNTY, OREGON

Record Number	Sample Number	Sample Location	Sample Type	Collection Date	Result units	XRF Result	XRF Reporting Limit	Qualifier
121	10EK-3001	Old Ore Furnace/Immediately Adjacent	Tailings	8/21/07	mg/kg	661	18.86	
122	10EK-3002	Old Ore Furnace/Immediately Adjacent	Tailings	8/21/07	mg/kg	181	9.66	
123	10EK-3003	Old Ore Furnace/Immediately Adjacent	Tailings	8/21/07	mg/kg	1940	32.34	
124	10EK-3004	Old Ore Furnace/Immediately Adjacent	Tailings	8/21/07	mg/kg	298	11.99	
125	10EK-3005	Old Ore Furnace/Immediately Adjacent	Tailings	8/21/07	mg/kg	33.5	5.66	
126	10EK-3006	Old Ore Furnace/Immediately Adjacent	Tailings	8/21/07	mg/kg	63.7	7.09	
127	10EK-3007	Old Ore Furnace/Immediately Adjacent	Tailings	8/21/07	mg/kg	34.4	5.93	
128	10EK-3008	Old Ore Furnace/Immediately Adjacent	Tailings	8/21/07	mg/kg	62.3	7.20	
129	10EK-3009	Old Ore Furnace/Immediately Adjacent	Tailings	8/21/07	mg/kg	186	9.50	
130	10EK-3010	Old Ore Furnace/Immediately Adjacent	Tailings	8/21/07	mg/kg	141	10.38	
131	10EK-3011	Old Ore Furnace/Immediately Adjacent	Tailings	8/21/07	mg/kg	208	10.44	
132	10EK-3012	Old Ore Furnace/Immediately Adjacent	Tailings	8/21/07	mg/kg	13.7	13.67	U
133	10EK-3013	Old Ore Furnace/Immediately Adjacent	Tailings	8/21/07	mg/kg	126	9.14	
134	10EK-3014	Old Ore Furnace/Immediately Adjacent	Tailings	8/21/07	mg/kg	40.9	5.72	
135	10EK-3015	Old Ore Furnace/Immediately Adjacent	Tailings	8/21/07	mg/kg	12.6	12.60	U
136	10EK-3016	Old Ore Furnace/Immediately Adjacent	Tailings	8/21/07	mg/kg	1500	29.03	
137	10EK-3017	Old Ore Furnace/Immediately Adjacent	Tailings	8/21/07	mg/kg	9730	109.93	
138	10EK-3018	Old Ore Furnace/Immediately Adjacent	Tailings	8/21/07	mg/kg	2880	41.06	
139	10EK-3019	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	2350	36.16	
140	10EK-3020	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	1960	32.03	
141	10EK-3021	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	42.6	42.60	U
142	10EK-3022	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	210	29.27	
143	10EK-3023	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	2160	76.39	
144	10EK-3024	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	10500	319.74	
145	10EK-3025	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	1490	66.14	
146	10EK-3026	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	917	58.57	
147	10EK-3027	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	96.3	23.63	
148	10EK-3028	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	229	24.15	
149	10EK-3029	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	38.7	38.69	U
150	10EK-3030	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	36.4	36.36	U
151	10EK-3031	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	346	30.60	
152	10EK-3032	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	552	41.01	

Table I-2
TOTAL MERCURY IN SAMPLES FROM OLD ORE FURNACE AREA
BLACK BUTTE MINE
LANE COUNTY, OREGON

Record Number	Sample Number	Sample Location	Sample Type	Collection Date	Result units	XRF Result	XRF Reporting Limit	Qualifier
153	10EK-3033	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	1180	61.40	
154	10EK-3034	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	1040	70.80	
155	10EK-3035	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	3090	127.80	
156	10EK-3036	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	723	48.87	
157	10EK-3037	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	123	21.08	
157	10EK-3037	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	123	21.08	
158	10EK-3038	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	42.6	42.56	U
159	10EK-3039	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	67.4	18.44	
160	10EK-3040	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	222	23.80	
161	10EK-3041	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	498	51.49	
162	10EK-3042	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	107	21.00	
163	10EK-3043	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	175	24.17	
164	10EK-3044	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	33.7	33.71	U
165	10EK-3045	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	56.5	16.11	
166	10EK-3046	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	47.6	47.63	U
167	10EK-3047	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	244	26.44	
168	10EK-3048	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	133	26.93	
169	10EK-3049	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	36.1	36.09	U
170	10EK-3050	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	118	21.44	
171	10EK-3051	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	203	10.55	
172	10EK-3052	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	84.8	7.57	
173	10EK-3053	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	12.9	12.87	U
174	10EK-3054	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	55.6	6.31	
175	10EK-3055	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	16.3	16.34	U
176	10EK-3056	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	622	18.90	
177	10EK-3057	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	985	20.15	
178	10EK-3058	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	3490	47.17	
179	10EK-3059	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	42.5	5.79	
180	10EK-3060	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	37.8	6.29	
181	10EK-3061	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	89.1	7.83	
182	10EK-3062	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	175	10.01	
183	10EK-3063	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	402	14.11	

Table I-2
TOTAL MERCURY IN SAMPLES FROM OLD ORE FURNACE AREA
BLACK BUTTE MINE
LANE COUNTY, OREGON

Record Number	Sample Number	Sample Location	Sample Type	Collection Date	Result units	XRF Result	XRF Reporting Limit	Qualifier
184	10EK-3064	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	1440	31.19	
185	10EK-3065	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	33.3	5.52	
186	10EK-3066	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	278	12.55	
187	10EK-3067	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	709	18.15	
188	10EK-3068	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	225	10.31	
189	10EK-3069	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	154	8.71	
190	10EK-3070	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	145	8.67	
191	10EK-3071	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	148	8.67	
192	10EK-3072	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	348	13.88	
193	10EK-3073	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	264	11.86	
194	10EK-3074	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	357	13.33	
195	10EK-3075	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	12.4	12.37	U
196	10EK-3076	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	909	21.25	
197	10EK-3077	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	2510	40.44	
198	10EK-3078	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	148	9.42	
199	10EK-3079	Old Ore Furnace/Upgradient	Tailings	8/21/07	mg/kg	41.0	6.23	
201	10EK-3081	Old Ore Furnace/Upgradient	Tailings	8/30/07	mg/kg	83.5	7.71	
202	10EK-3082	Old Ore Furnace/Upgradient	Tailings	8/30/07	mg/kg	41.7	5.57	
204	10EK-3084	Old Ore Furnace/Upgradient	Tailings	8/30/07	mg/kg	117	7.74	
206	10EK-3086	Old Ore Furnace/Upgradient	Tailings	8/30/07	mg/kg	614	15.56	
207	10EK-3087	Old Ore Furnace/Upgradient	Tailings	8/30/07	mg/kg	493	14.28	
619	10EK-3089	Old Ore Furnace/Confirmation	Tailings	9/3/07	mg/kg	14.4	14.44	U
620	10EK-3090	Old Ore Furnace/Confirmation	Tailings	9/3/07	mg/kg	12.8	12.79	U
621	10EK-3091	Old Ore Furnace/Confirmation	Tailings	9/3/07	mg/kg	22.9	6.54	
622	10EK-3092	Old Ore Furnace/Confirmation	Tailings	9/3/07	mg/kg	12.5	12.45	U
623	10EK-3093	Old Ore Furnace/Confirmation	Tailings	9/3/07	mg/kg	14.6	14.64	U
624	10EK-3094	Old Ore Furnace/Confirmation	Tailings	9/3/07	mg/kg	16.2	16.22	U
625	10EK-3095	Old Ore Furnace/Confirmation	Tailings	9/3/07	mg/kg	16.2	16.22	U
626	10EK-3096	Old Ore Furnace/Confirmation	Tailings	9/3/07	mg/kg	14.9	14.93	U
627	10EK-3097	Old Ore Furnace/Confirmation	Tailings	9/3/07	mg/kg	14.2	14.20	U
628	10EK-3098	Old Ore Furnace/Confirmation	Tailings	9/3/07	mg/kg	12.6	12.56	U
629	10EK-3099	Old Ore Furnace/Confirmation	Tailings	9/3/07	mg/kg	16.1	16.06	U

Table I-2
TOTAL MERCURY IN SAMPLES FROM OLD ORE FURNACE AREA
BLACK BUTTE MINE
LANE COUNTY, OREGON

Record Number	Sample Number	Sample Location	Sample Type	Collection Date	Result units	XRF Result	XRF Reporting Limit	Qualifier
630	10EK-3100	Old Ore Furnace/Confirmation	Tailings	9/3/07	mg/kg	16.8	16.83	U
631	10EK-3101	Old Ore Furnace/Confirmation	Tailings	9/3/07	mg/kg	14.4	14.38	U
632	10EK-3102	Old Ore Furnace/Confirmation	Tailings	9/3/07	mg/kg	14.9	14.91	U
633	10EK-3103	Old Ore Furnace/Confirmation	Tailings	9/3/07	mg/kg	16.1	16.11	U
634	10EK-3104	Old Ore Furnace/Confirmation	Tailings	9/3/07	mg/kg	17.3	4.88	
635	10EK-3105	Old Ore Furnace/Confirmation	Tailings	9/3/07	mg/kg	12.9	12.85	U
636	10EK-3106	Old Ore Furnace/Confirmation	Tailings	9/3/07	mg/kg	22.0	5.79	
637	10EK-3107	Old Ore Furnace/Confirmation	Tailings	9/3/07	mg/kg	15.0	15.04	U
638	10EK-3108	Old Ore Furnace/Confirmation	Tailings	9/3/07	mg/kg	15.5	15.50	U
639	10EK-3109	Old Ore Furnace/Confirmation	Tailings	9/3/07	mg/kg	15.0	15.04	U
552	10EK-7001	Old Ore Furnace/Downgradient	Tailings	8/28/07	mg/kg	84	18.45	
553	10EK-7002	Old Ore Furnace/Downgradient	Tailings	8/28/07	mg/kg	53	15.17	
554	10EK-7003	Old Ore Furnace/Downgradient	Tailings	8/28/07	mg/kg	195	29.05	
555	10EK-7004	Old Ore Furnace/Downgradient	Tailings	8/28/07	mg/kg		49.17	U
556	10EK-7005	Old Ore Furnace/Downgradient	Tailings	8/28/07	mg/kg	59	15.51	
557	10EK-7006	Old Ore Furnace/Downgradient	Tailings	8/28/07	mg/kg	194	25.55	
558	10EK-7007	Old Ore Furnace/Downgradient	Tailings	8/28/07	mg/kg	262	32.42	
559	10EK-7008	Old Ore Furnace/Downgradient	Tailings	8/28/07	mg/kg	481	39.84	
560	10EK-7009	Old Ore Furnace/Downgradient	Tailings	8/28/07	mg/kg	790	55.97	
561	10EK-7010	Old Ore Furnace/Downgradient	Tailings	8/28/07	mg/kg	579	37.83	
562	10EK-7011	Old Ore Furnace/Downgradient	Tailings	8/28/07	mg/kg	111	19.82	
563	10EK-7012	Old Ore Furnace/Downgradient	Tailings	8/28/07	mg/kg	1205	63.26	
564	10EK-7013	Old Ore Furnace/Downgradient	Tailings	8/28/07	mg/kg	1124	64.25	

TABLE I-4
TOTAL MERCURY IN TAILINGS/SEDIMENT/SOIL FROM FURNACE CREEK AND FURNACE CREEK BANKS
BLACK BUTTE MINE
LANE COUNTY, OREGON

Record Number	Sample Number	Sample Location	Sample Type	Collection Date	Result units	XRF/ Lumex Result	XRF/ Lumex Reporting Limit	Qualifier
209	10EK-4001	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	2.06	0.50	
210	10EK-4002	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	3.51	0.50	
211	10EK-4003	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	2.16	0.50	
212	10EK-4004	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	2.24	0.50	
213	10EK-4005	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	2.61	0.50	
214	10EK-4006	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	2.97	0.50	
215	10EK-4007	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	2.70	0.50	
216	10EK-4008	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	2.46	0.50	
217	10EK-4009	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	1.81	0.50	
218	10EK-4010	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	5.39	0.50	
219	10EK-4011	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	2.77	0.50	
220	10EK-4012	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	3.87	0.50	
221	10EK-4013	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	1.62	0.50	
222	10EK-4014	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	2.49	0.50	
223	10EK-4015	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	3.34	0.50	
224	10EK-4016	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	1.95	0.50	
225	10EK-4017	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	2.36	0.50	
226	10EK-4018	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	1.68	0.50	
227	10EK-4019	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	1.76	0.50	
228	10EK-4020	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	2.58	0.50	
229	10EK-4021	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	2.91	0.50	
231	10EK-4022	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	1.94	0.50	
232	10EK-4023	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	29.2	0.50	
233	10EK-4024	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	103	0.50	
234	10EK-4025	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	271	0.50	J
235	10EK-4026	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	42.4	0.50	
236	10EK-4027	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	63.2	0.50	
237	10EK-4028	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	146	0.50	
238	10EK-4029	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	78.3	0.50	
239	10EK-4030	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	141	0.50	
240	10EK-4031	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	73.9	0.50	

TABLE I-4
TOTAL MERCURY IN TAILINGS/SEDIMENT/SOIL FROM FURNACE CREEK AND FURNACE CREEK BANKS
BLACK BUTTE MINE
LANE COUNTY, OREGON

Record Number	Sample Number	Sample Location	Sample Type	Collection Date	Result units	XRF/ Lumex Result	XRF/ Lumex Reporting Limit	Qualifier
	10EK-4031	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	73.9	0.50	
241	10EK-4032	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	78.8	0.50	
242	10EK-4033	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	81.9	0.50	
243	10EK-4034	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	115	0.50	
244	10EK-4035	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	258	0.50	J
245	10EK-4036	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	184	0.50	J
246	10EK-4037	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	486	0.50	J
247	10EK-4038	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	191	0.50	J
248	10EK-4039	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	300	0.50	J
249	10EK-4040	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	159	0.50	J
250	10EK-4041	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	212	0.50	J
251	10EK-4042	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	140	0.50	
252	10EK-4043	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	21.1	0.50	
253	10EK-4044	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	23.0	0.50	
254	10EK-4045	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	108	0.50	
255	10EK-4046	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	229	0.50	J
256	10EK-4047	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	265	0.50	J
257	10EK-4048	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	130	0.50	
258	10EK-4049	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	150	0.50	
259	10EK-4050	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	133	0.50	
260	10EK-4051	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	138	0.50	
261	10EK-4052	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	106	0.50	
262	10EK-4053	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	74.4	0.50	
263	10EK-4054	Furnace Creek/within Creek	Sediment/Tailings	8/23/07	mg/kg	70.7	0.50	
264	10EK-4055	Furnace Creek/within Creek	Sediment/Tailings	8/28/07	mg/kg	36.8	0.50	
265	10EK-4056	Furnace Creek/within Creek	Sediment/Tailings	8/28/07	mg/kg	87.5	0.50	
266	10EK-4057	Furnace Creek/within Creek	Sediment/Tailings	8/28/07	mg/kg	130	0.50	
267	10EK-4058	Furnace Creek/within Creek	Sediment/Tailings	8/28/07	mg/kg	47.4	0.50	
269	10EK-4059	Furnace Creek/within Creek	Sediment/Tailings	8/28/07	mg/kg	103	0.50	
270	10EK-4060	Furnace Creek/within Creek	Sediment/Tailings	8/28/07	mg/kg	72.1	0.50	
271	10EK-4061	Furnace Creek/within Creek	Sediment/Tailings	8/28/07	mg/kg	74.9	0.50	

TABLE I-4
TOTAL MERCURY IN TAILINGS/SEDIMENT/SOIL FROM FURNACE CREEK AND FURNACE CREEK BANKS
BLACK BUTTE MINE
LANE COUNTY, OREGON

Record Number	Sample Number	Sample Location	Sample Type	Collection Date	Result units	XRF/ Lumex Result	XRF/ Lumex Reporting Limit	Qualifier
272	10EK-4062	Furnace Creek/within Creek	Sediment/Tailings	8/28/07	mg/kg	108	0.50	
273	10EK-4064	Furnace Creek/within Creek	Sediment/Tailings	8/28/07	mg/kg	109	0.50	
274	10EK-4065	Furnace Creek/within Creek	Sediment/Tailings	8/28/07	mg/kg	38.0	0.50	
275	10EK-4066	Furnace Creek/within Creek	Sediment/Tailings	8/28/07	mg/kg	56.9	0.50	
276	10EK-4067	Furnace Creek/within Creek	Sediment/Tailings	8/28/07	mg/kg	86.2	0.50	
277	10EK-4068	Furnace Creek/within Creek	Sediment/Tailings	8/28/07	mg/kg	39.0	0.50	
278	10EK-4069	Furnace Creek/within Creek	Sediment/Tailings	8/28/07	mg/kg	70.8	5.61	
279	10EK-4070	Furnace Creek/within Creek	Sediment/Tailings	8/28/07	mg/kg	104	6.75	
280	10EK-4071	Furnace Creek/within Creek	Sediment/Tailings	8/28/07	mg/kg	181	0.50	J
281	10EK-4072	Furnace Creek/within Creek	Sediment/Tailings	8/28/07	mg/kg	74.9	0.50	
282	10EK-4101	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	0.08	0.50	U
283	10EK-4102	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	1.64	0.50	
284	10EK-4103	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	0.93	0.50	
285	10EK-4104	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	1.18	0.50	
286	10EK-4105	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	0.86	0.50	
287	10EK-4106	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	0.51	0.50	
288	10EK-4107	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	0.18	0.50	U
289	10EK-4108	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	1.17	0.50	
290	10EK-4109	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	1.86	0.50	
291	10EK-4110	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	1.88	0.50	
292	10EK-4111	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	1.08	0.50	
293	10EK-4112	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	0.87	0.50	
294	10EK-4113	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	1.39	0.50	
295	10EK-4114	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	1.24	0.50	
296	10EK-4115	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	16.0	0.50	
297	10EK-4116	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	3.99	0.50	
298	10EK-4117	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	1.66	0.50	
299	10EK-4118	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	1.08	0.50	
300	10EK-4119	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	2.00	0.50	
301	10EK-4120	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	0.77	0.50	
302	10EK-4121	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	1.01	0.50	

TABLE I-4
TOTAL MERCURY IN TAILINGS/SEDIMENT/SOIL FROM FURNACE CREEK AND FURNACE CREEK BANKS
BLACK BUTTE MINE
LANE COUNTY, OREGON

Record Number	Sample Number	Sample Location	Sample Type	Collection Date	Result units	XRF/ Lumex Result	XRF/ Lumex Reporting Limit	Qualifier
303	10EK-4122	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	0.18	0.50	U
304	10EK-4123	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	10.6	10.60	U
305	10EK-4124	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	9160	107.27	
306	10EK-4125	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	0.00	0.00	
307	10EK-4126	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	45.2	5.67	
308	10EK-4127	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	0.00	0.00	
309	10EK-4128	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	55.0	6.01	
310	10EK-4129	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	0.00	0.00	
311	10EK-4130	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	3.24	0.50	
312	10EK-4131	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	5.68	0.50	
313	10EK-4132	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	6.69	0.50	
314	10EK-4133	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	27.0	0.50	
315	10EK-4134	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	6.12	0.50	
316	10EK-4135	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	30.7	5.39	
317	10EK-4136	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	0.00	0.00	
318	10EK-4137	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	26.7	0.50	
319	10EK-4138	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	14.3	14.27	U
320	10EK-4139	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	0.00	0.00	
321	10EK-4140	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	34.2	0.50	
	10EK-4140	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	34.2	0.50	
322	10EK-4141	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	23.2	0.50	
323	10EK-4142	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	41.1	0.50	
324	10EK-4143	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	35.8	0.50	
325	10EK-4144	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	26.9	0.50	
326	10EK-4145	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	18.8	0.50	
327	10EK-4146	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	91.5	0.50	
328	10EK-4147	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	20.9	0.50	
329	10EK-4148	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	56.0	0.50	
330	10EK-4149	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	52.2	0.50	
331	10EK-4150	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	31.9	0.50	
332	10EK-4151	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	82.5	6.73	

TABLE I-4
TOTAL MERCURY IN TAILINGS/SEDIMENT/SOIL FROM FURNACE CREEK AND FURNACE CREEK BANKS
BLACK BUTTE MINE
LANE COUNTY, OREGON

Record Number	Sample Number	Sample Location	Sample Type	Collection Date	Result units	XRF/ Lumex Result	XRF/ Lumex Reporting Limit	Qualifier
333	10EK-4152	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	39.7	0.50	
334	10EK-4153	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	13.3	0.50	
335	10EK-4154	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/23/07	mg/kg	36.2	0.50	
336	10EK-4155	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/28/07	mg/kg	60.0	0.00	
337	10EK-4156	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/28/07	mg/kg	62.0	0.00	
338	10EK-4157	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/28/07	mg/kg	26.8	0.50	
339	10EK-4158	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/28/07	mg/kg	35.0	0.00	
340	10EK-4159	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/28/07	mg/kg	77.0	0.00	
341	10EK-4160	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/28/07	mg/kg	2.78	0.50	
342	10EK-4161	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/28/07	mg/kg	56.9	0.50	
343	10EK-4162	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/28/07	mg/kg	41.2	0.50	
344	10EK-4164	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/28/07	mg/kg	70.5	7.34	
345	10EK-4165	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/28/07	mg/kg	1520	25.52	
346	10EK-4166	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/28/07	mg/kg	150	8.39	
347	10EK-4167	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/28/07	mg/kg	85.3	7.14	
348	10EK-4168	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/28/07	mg/kg	279	10.76	
349	10EK-4169	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/28/07	mg/kg	117	0.50	
350	10EK-4170	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/28/07	mg/kg	69.0	0.50	
351	10EK-4171	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/28/07	mg/kg	137	8.15	
352	10EK-4172	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/28/07	mg/kg	24.8	0.50	
353	10EK-4173	Furnace Creek/Bank Sample NE Side - 5 ft	Tailings/Soil	8/28/07	mg/kg	6.71	0.50	
354	10EK-4201	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	1.70	0.50	
355	10EK-4202	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	1.49	0.50	
356	10EK-4203	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	1.15	0.50	
357	10EK-4204	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	0.66	0.50	
358	10EK-4205	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	1.46	0.50	
359	10EK-4206	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	0.87	0.50	
360	10EK-4207	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	1.01	0.50	
361	10EK-4208	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	1.93	0.50	
362	10EK-4209	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	0.82	0.50	
363	10EK-4210	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	0.80	0.50	

TABLE I-4
TOTAL MERCURY IN TAILINGS/SEDIMENT/SOIL FROM FURNACE CREEK AND FURNACE CREEK BANKS
BLACK BUTTE MINE
LANE COUNTY, OREGON

Record Number	Sample Number	Sample Location	Sample Type	Collection Date	Result units	XRF/ Lumex Result	XRF/ Lumex Reporting Limit	Qualifier
364	10EK-4211	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	0.59	0.50	
365	10EK-4212	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	1.28	0.50	
366	10EK-4213	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	1.38	0.50	
367	10EK-4214	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	0.61	0.50	
368	10EK-4215	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	0.47	0.50	U
369	10EK-4216	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	0.90	0.50	
370	10EK-4217	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	2.04	0.50	
371	10EK-4218	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	1.31	0.50	
372	10EK-4219	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	0.86	0.50	
373	10EK-4220	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	0.62	0.50	
374	10EK-4221	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	1.54	0.50	
375	10EK-4222	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	1.34	0.50	
376	10EK-4223	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	1.21	0.50	
377	10EK-4224	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	148	8.23	
378	10EK-4225	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	101	7.38	
379	10EK-4226	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	100	7.46	
380	10EK-4227	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	7.98	0.50	
381	10EK-4228	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	220	10.87	
382	10EK-4229	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	0.88	0.50	
383	10EK-4230	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	286	11.96	
384	10EK-4231	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	17.3	0.50	
	10EK-4231	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	17	0.50	
385	10EK-4232	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	0.61	0.50	
386	10EK-4233	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	7.85	0.50	
387	10EK-4234	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	3.78	0.50	
388	10EK-4235	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	0.00	0.00	
389	10EK-4236	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	139	8.59	
390	10EK-4237	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	358	12.35	
391	10EK-4238	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	47.6	5.73	
392	10EK-4239	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	0.00	0.00	
393	10EK-4240	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	37.1	5.21	

TABLE I-4
TOTAL MERCURY IN TAILINGS/SEDIMENT/SOIL FROM FURNACE CREEK AND FURNACE CREEK BANKS
BLACK BUTTE MINE
LANE COUNTY, OREGON

Record Number	Sample Number	Sample Location	Sample Type	Collection Date	Result units	XRF/ Lumex Result	XRF/ Lumex Reporting Limit	Qualifier
394	10EK-4241	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	12.6	0.50	
395	10EK-4242	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	34.7	0.50	
396	10EK-4243	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	0.00	0.00	
397	10EK-4244	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	54.7	5.90	
398	10EK-4245	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	27.9	0.50	
399	10EK-4246	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	0.00	0.00	
400	10EK-4247	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	107	5.55	
401	10EK-4248	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	36.0	5.01	
402	10EK-4249	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	27.9	0.50	
403	10EK-4250	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	29.6	0.50	
404	10EK-4251	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	30.7	0.50	
405	10EK-4252	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	5.26	0.50	
406	10EK-4253	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	0.00	0.50	
407	10EK-4254	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/23/07	mg/kg	40.0	0.00	
408	10EK-4255	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/28/07	mg/kg	55.0	0.50	
409	10EK-4256	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/28/07	mg/kg	0.00	0.50	
410	10EK-4257	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/28/07	mg/kg	66.0	0.00	
411	10EK-4258	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/28/07	mg/kg	51.0	0.00	
412	10EK-4259	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/28/07	mg/kg	0.00	0.50	
413	10EK-4260	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/28/07	mg/kg	79.0	0.00	
414	10EK-4261	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/28/07	mg/kg	18.4	4.87	
415	10EK-4262	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/28/07	mg/kg	28.3	0.50	
416	10EK-4264	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/28/07	mg/kg	57.8	0.50	
417	10EK-4265	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/28/07	mg/kg	22.1	0.50	
418	10EK-4266	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/28/07	mg/kg	35.8	0.50	
419	10EK-4267	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/28/07	mg/kg	0.00	0.50	
420	10EK-4268	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/28/07	mg/kg	225	10.17	
421	10EK-4269	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/28/07	mg/kg	28.9	4.28	
422	10EK-4270	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/28/07	mg/kg	0.00	0.50	
423	10EK-4271	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/28/07	mg/kg	34.1	5.38	
424	10EK-4272	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/28/07	mg/kg	29.2	0.50	

TABLE I-4
TOTAL MERCURY IN TAILINGS/SEDIMENT/SOIL FROM FURNACE CREEK AND FURNACE CREEK BANKS
BLACK BUTTE MINE
LANE COUNTY, OREGON

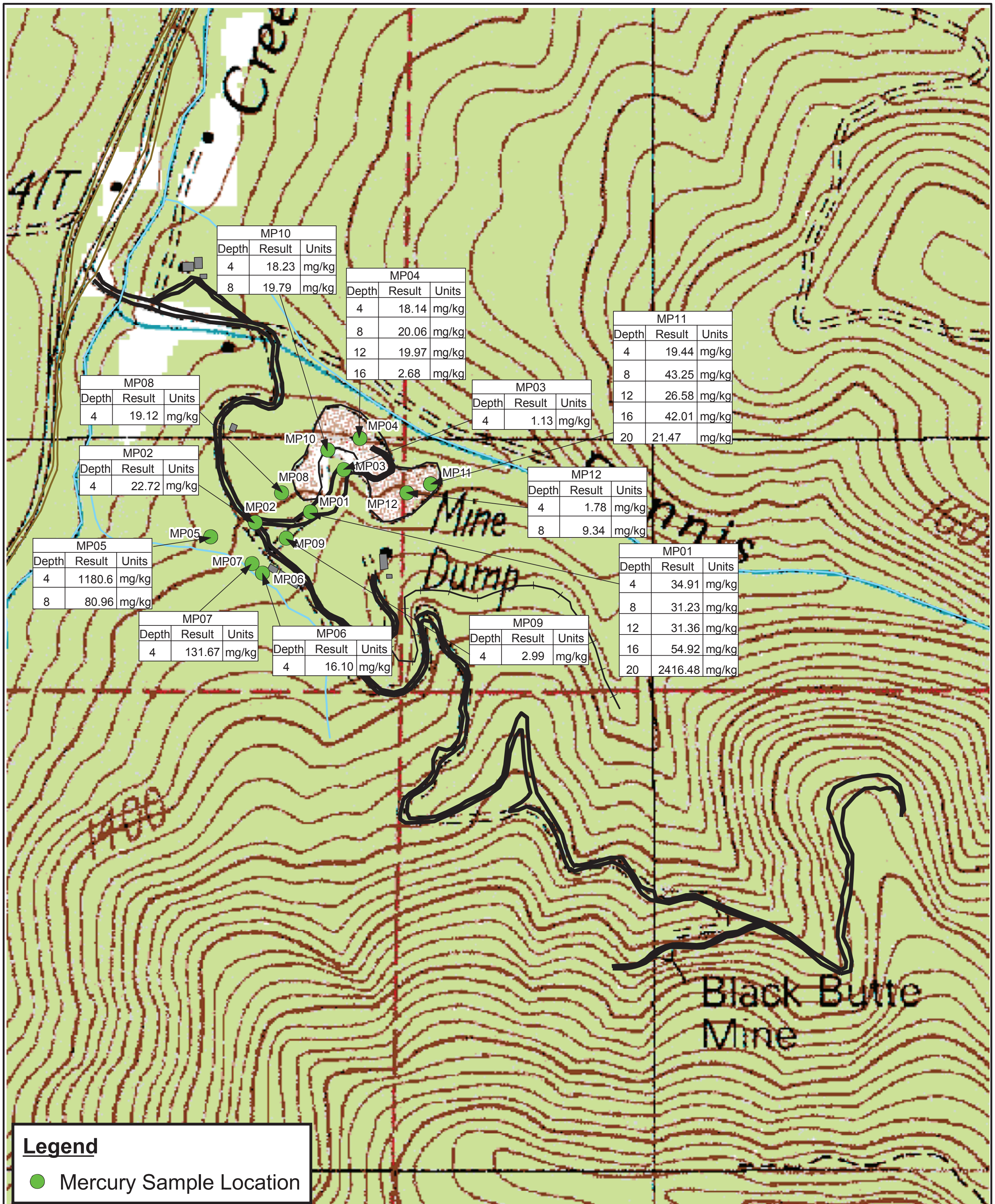
Record Number	Sample Number	Sample Location	Sample Type	Collection Date	Result units	XRF/ Lumex Result	XRF/ Lumex Reporting Limit	Qualifier
425	10EK-4273	Furnace Creek/Bank Sample NE Side - 10 ft	Tailings/Soil	8/28/07	mg/kg	24.0	0.50	
426	10EK-4301	Furnace Creek/Specific Target on NE Side	Sediment/Tailings	8/29/07	mg/kg	0.00	0.00	
427	10EK-4302	Furnace Creek/Specific Target on NE Side	Sediment/Tailings	8/29/07	mg/kg	16.8	16.83	U
428	10EK-4303	Furnace Creek/Specific Target on NE Side	Sediment/Tailings	8/29/07	mg/kg	12.6	3.87	
429	10EK-4304	Furnace Creek/Specific Target on NE Side	Sediment/Tailings	8/29/07	mg/kg	25.4	5.29	
430	10EK-4305	Furnace Creek/Specific Target on NE Side	Sediment/Tailings	8/29/07	mg/kg	99.9	7.66	
431	10EK-4306	Furnace Creek/Specific Target on NE Side	Sediment/Tailings	8/29/07	mg/kg	384	13.08	
432	10EK-4307	Furnace Creek/Specific Target on NE Side	Sediment/Tailings	8/29/07	mg/kg	750	17.41	
433	10EK-4308	Furnace Creek/Specific Target on NE Side	Sediment/Tailings	8/29/07	mg/kg	2470	36.27	
434	10EK-4309	Furnace Creek/Specific Target on NE Side	Sediment/Tailings	8/29/07	mg/kg	2920	41.18	
435	10EK-4369	Furnace Creek/Specific Target on NE Side	Sediment/Tailings	8/28/07	mg/kg	141	8.29	
437	10EK-4371	Furnace Creek/Specific Target on NE Side	Sediment/Tailings	8/28/07	mg/kg	7.95	0.50	
438	10EK-4469	Furnace Creek/Specific Target on NE Side	Sediment/Tailings	8/28/07	mg/kg	10.1	0.50	
439	10EK-4471	Furnace Creek/Specific Target on NE Side	Sediment/Tailings	8/28/07	mg/kg	6.05	0.50	
475	10EK-6101	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	21.2	0.5	
476	10EK-6102	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	2.28	0.5	
477	10EK-6103	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	12.9	0.5	
478	10EK-6104	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	7.66	0.5	
479	10EK-6105	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	12.0	0.5	
480	10EK-6106	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	3.36	0.5	
481	10EK-6107	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	1.90	0.5	
482	10EK-6108	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	6.13	0.5	
483	10EK-6109	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	3.07	0.5	
484	10EK-6110	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	2.99	0.5	
485	10EK-6111	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	2.40	0.5	
486	10EK-6112	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	2.91	0.5	
487	10EK-6113	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	2.46	0.5	
488	10EK-6114	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	1.71	0.5	
489	10EK-6115	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	5.25	0.5	
490	10EK-6116	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	1.24	0.5	U
491	10EK-6117	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	11.1	0.5	

TABLE I-4
TOTAL MERCURY IN TAILINGS/SEDIMENT/SOIL FROM FURNACE CREEK AND FURNACE CREEK BANKS
BLACK BUTTE MINE
LANE COUNTY, OREGON

Record Number	Sample Number	Sample Location	Sample Type	Collection Date	Result units	XRF/ Lumex Result	XRF/ Lumex Reporting Limit	Qualifier
492	10EK-6118	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	27.5	0.5	
493	10EK-6119	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	2.21	0.5	
494	10EK-6120	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	0.82	0.5	U
495	10EK-6121	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	9.53	0.5	
496	10EK-6122	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	11.4	0.5	
497	10EK-6123	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	0.60	0.5	U
498	10EK-6124	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	10.7	0.5	
499	10EK-6125	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	2.59	0.5	
500	10EK-6126	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	9.72	0.5	
501	10EK-6127	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	25.7	0.5	
502	10EK-6128	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	1.75	0.5	
503	10EK-6129	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	3.21	0.5	
504	10EK-6130	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	87.2	0.5	J
505	10EK-6131	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	29.7	0.5	
506	10EK-6132	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	28.7	0.5	
507	10EK-6133	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	14.2	0.5	
508	10EK-6134	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	10.6	0.5	
509	10EK-6135	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	267	0.5	J
510	10EK-6136	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	204	0.5	J
511	10EK-6137	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	85.4	0.5	J
512	10EK-6138	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	125	0.5	J
513	10EK-6139	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	85.8	0.5	J
514	10EK-6140	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	35.9	0.5	
515	10EK-6141	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	9.40	0.5	
516	10EK-6142	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	14.7	0.5	
517	10EK-6143	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	334	11.4	
518	10EK-6144	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	55.3	0.5	
519	10EK-6145	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	29.0	0.5	
520	10EK-6146	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	142	0.5	J
521	10EK-6147	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	22.9	0.5	
522	10EK-6148	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	63.9	0.5	

TABLE I-4
TOTAL MERCURY IN TAILINGS/SEDIMENT/SOIL FROM FURNACE CREEK AND FURNACE CREEK BANKS
BLACK BUTTE MINE
LANE COUNTY, OREGON

Record Number	Sample Number	Sample Location	Sample Type	Collection Date	Result units	XRF/ Lumex Result	XRF/ Lumex Reporting Limit	Qualifier
523	10EK-6149	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	34.7	0.5	
524	10EK-6150	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	31.5	0.5	
525	10EK-6151	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	63.4	0.5	
526	10EK-6152	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	40.8	0.5	
527	10EK-6153	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	33.3	0.5	
528	10EK-6154	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	18.0	0.5	
529	10EK-6155	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	11.5	0.5	
530	10EK-6156	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	34.7	0.5	
531	10EK-6157	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	16.0	0.5	
532	10EK-6158	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	4.85	0.5	
533	10EK-6159	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	4.92	0.5	
534	10EK-6160	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	61.1	0.5	
535	10EK-6161	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	99.4	0.5	J
536	10EK-6162	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	49.4	0.5	
537	10EK-6163	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	58.5	0.5	
538	10EK-6164	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	47.2	0.5	
539	10EK-6165	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	79.5	0.5	
540	10EK-6166	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	212	10.0	
541	10EK-6167	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	266	10.6	
542	10EK-6168	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/29/07	mg/kg	59.2	0.5	
543	10EK-6169	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/28/07	mg/kg	43.3	0.5	J
544	10EK-6170	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/28/07	mg/kg	43.4	0.5	
545	10EK-6171	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/28/07	mg/kg	26.2	0.5	
546	10EK-6172	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/28/07	mg/kg	31.6	0.5	
547	10EK-6269	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/28/07	mg/kg	32.6	0.5	
548	10EK-6270	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/28/07	mg/kg	31.4	0.5	
549	10EK-6271	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/28/07	mg/kg	18.6	0.5	
550	10EK-6272	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/28/07	mg/kg	10.2	0.5	
551	10EK-6273	Furnace Creek/Bank Sample SW Side - 5 ft	Sediment/Tailings	8/28/07	mg/kg	16.9	0.5	



0 125 250 500 750

Feet

Scale 1:7,500

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Figure 5-1a

WASTE ROCK/TAILINGS SAMPLE LOCATION MAP AND TOTAL MERCURY RESULTS

BLACK BUTTE MINE

Lane County, Oregon

Job Id: 002233.0026.01IA

Date: 1/20/06

GIS Analyst: avh

Map Source Information: USGS Topographic Map. Harness Mountain, Oregon. Scale 1-24,000 .

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Table 5-2

**TOTAL MERCURY AND ARSENIC IN WASTE ROCK/TAILINGS SAMPLES
FROM REMOVAL ASSESSMENT AND SITE INSPECTION
BLACK BUTTE MINE
LANE COUNTY, OREGON**

Sample Number	Sample Location/Identification (depth)	Units	Total Mercury			
			XRF	+/-	Lumex	Fixed Laboratory
	Environmental Protection Agency Region 9 PRGs	mg/kg	23			
Removal Assessment (September 2005)						
MP01SS04	Main Tailings Pile/Borehole 1 (0 - 4 ft bgs)	mg/kg	**34.91**	5.64	**30.7**	--
MP01SS08	Main Tailings Pile/Borehole 1 (4 - 8 ft bgs)	mg/kg	**31.23**	5.26	12.9	--
MP01SS12	Main Tailings Pile/Borehole 1 (8 - 12 ft bgs)	mg/kg	**31.36**	5.21	**39.3**	7.35
MP01SS16	Main Tailings Pile/Borehole 1 (12 - 16 ft bgs)	mg/kg	**54.92**	6.22	12.7	--
MP01SS20	Main Tailings Pile/Borehole 1 (16 - 20 ft bgs)	mg/kg	**2,416.48**	43.79	1.7	0.808
MP02SS04	Main Tailings Pile/Borehole 2 (0 - 4 ft bgs)	mg/kg	22.72	4.94	16.8	--
MP02SS08	Main Tailings Pile/Borehole 2 (4 - 8 ft bgs)	mg/kg	N/A	N/A	0.75 J	--
MP03SS04	Main Tailings Pile/Borehole 3 (0 - 4 ft bgs)	mg/kg	1.13	5.32	0.14 J	--
MP04SS04	Main Tailings Pile/Borehole 4 (0 - 4 ft bgs)	mg/kg	18.14	6.6	0.95 J	--
MP04SS08	Main Tailings Pile/Borehole 4 (4 - 8 ft bgs)	mg/kg	20.06	4.7	6.1	--
MP04SS12	Main Tailings Pile/Borehole 4 (8 - 12 ft bgs)	mg/kg	19.97	5.67	3.1	--
MP04SS16	Main Tailings Pile/Borehole 4 (12 - 16 ft bgs)	mg/kg	2.68	3.51	0.8 J	--
MP05SS04	Old Furnace Area/Borehole 5 (0 - 4 ft bgs)	mg/kg	**1,180.6**	26.85	**68.6**	17.7
MP05SS08	Old Furnace Area/Borehole 5 (4 - 8 ft bgs)	mg/kg	**80.96**	7.95	**45**	--
MP06SS04	Old Furnace Area/Borehole 6 (0 - 4 ft bgs)	mg/kg	16.1	4.15	**386**	--
MP07SS04	Old Furnace Area/Borehole 7 (0 - 4 ft bgs)	mg/kg	**131.67**	8.7	**145**	3.83
MP08SS04	Main Tailings Pile/Borehole 8 (0 - 4 ft bgs)	mg/kg	19.12	4.57	6.5	--
MP09SS04	Main Tailings Pile/Borehole 9 (0 - 4 ft bgs)	mg/kg	2.99	3.99	1.5	5.42
MP10SS04	Main Tailings Pile/Borehole 10 (0 - 4 ft bgs)	mg/kg	18.23	4.74	0.89 J	--
MP10SS08B	Main Tailings Pile/Borehole 10 (4 - 8 ft bgs)	mg/kg	14.42	4.46	4.6	--
MP10SS08A	Main Tailings Pile/Borehole 10 (4 - 8 ft bgs)	mg/kg	19.79	6.6	5.2	--
MP11SS04	Main Tailings Pile/Borehole 11 (0 - 4 ft bgs)	mg/kg	19.44	4.64	2.8	--
MP11SS08	Main Tailings Pile/Borehole 11 (4 - 8 ft bgs)	mg/kg	**43.25**	5.86	0.95 J	--
MP11SS12	Main Tailings Pile/Borehole 11 (8 - 12 ft bgs)	mg/kg	**26.58**	5.44	2.5	--
MP11SS16	Main Tailings Pile/Borehole 11 (12 - 16 ft bgs)	mg/kg	**42.01**	5.89	2.4	--
MP11SS20	Main Tailings Pile/Borehole 11 (16 - 20 ft bgs)	mg/kg	21.47	5.01	1.2 J	--
MP12SS04	New Furnace Area/Borehole 12 (0 - 4 ft bgs)	mg/kg	1.78	3.23	8.8	--
MP12SS08	New Furnace Area/Borehole 12 (4 - 8 ft bgs)	mg/kg	9.34	4	N/A	0.952

DRILLING LOG OF BORING NO. MP05

DATE DRILLED: 9/8/2005
LOGGED BY: M. Longtine
CHECKED BY: E. Lynch
DRILLING CONTRACTOR: E&E/START
DRILLED BY: A. Jensen
DRILLING METHOD: GEOPROBE DIRECT PUSH

VERTICAL DATUM:
LOCATION: BLACK BUTTE MINE

PROJECT: Black Butte Mine
TDD #: 05-04-0005
PROJECT LOCATION: Cottage Grove, Oregon

EPA PROJ MGR: M. Callaghan
START-2 PROJ MGR: E. Lynch
E & E PROJ #: 001281.0478.01IA

ELEVATION	DEPTH (feet)	USCS	GRAPHIC LOG	SOIL DESCRIPTION	SAMPLE COLLECTION TIME	SAMPLE ID	COMMENTS
				Top of Ground Surface (GS) Elevation			This log is part of the report prepared for the named project and should be read together with that report for complete interpretation. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplification of actual conditions encountered.
	0–8	ML		Native soil - Tailings appear at surface (see comment section), Clay silt with local rock fragments, Yellowish brown; Hard, compact; Dry.	1440	MP05SS04	Tailings evident on the surface at this location, possibly moved into place by the front end loader this morning during clearing operations. However, no tailings present in subsurface. Scotch broom, an otherwise useful indicator of recently vegetated tailings, misleading here.
					1450	MP05SS08	
	8.0						Total depth 8 feet BGS. Abandoned by backfilling to surface with 3/8 inch bentonite chips.

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

START BBM BORING LOG BBM2005.GPJ E&E PORTLAND.GDT 1/20/06

ecology and environment, inc.
333 SW Fifth Avenue
Suite 608
Portland, OR 97204
Phone: 503-248-5600 Fax: 503-248-5577

*** DRAFT ***

DRILLING LOG OF BORING NO. MP06

DATE DRILLED: 9/8/2005
LOGGED BY: M. Longtine
CHECKED BY: E. Lynch
DRILLING CONTRACTOR: E&E/START
DRILLED BY: A. Jensen
DRILLING METHOD: GEOPROBE DIRECT PUSH

VERTICAL DATUM:
LOCATION: BLACK BUTTE MINE

PROJECT: Black Butte Mine
TDD #: 05-04-0005
PROJECT LOCATION: Cottage Grove, Oregon

EPA PROJ MGR: M. Callaghan
START-2 PROJ MGR: E. Lynch
E & E PROJ #: 001281.0478.01IA

ELEVATION	DEPTH (feet)	USCS	GRAPHIC LOG	SOIL DESCRIPTION	SAMPLE COLLECTION TIME	SAMPLE ID	COMMENTS
				Top of Ground Surface (GS) Elevation			This log is part of the report prepared for the named project and should be read together with that report for complete interpretation. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplification of actual conditions encountered.
		FILL		0.3 Fill - Silt; Grayish Purple; Dry			
	1, 2, 3	ML		Native Soil - silt - clay mixture with minor local rock fragments, Rusty brown; Dry.	1530	MP06SS04	
	4			4.0			Total depth 4 feet BGS. Abandoned by backfilling to surface with 3/8 inch bentonite chips.
	5, 6, 7, 8, 9, 10						

START BBM BORING LOG BBM2005.GPJ E&E PORTLAND.GDT 1/20/06

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Suite 608
Portland, OR 97204
Phone: 503-248-5600 Fax: 503-248-5577

*** DRAFT ***

DRILLING LOG OF BORING NO. MP07

DATE DRILLED: 9/8/2005
LOGGED BY: M. Longtine
CHECKED BY: E. Lynch
DRILLING CONTRACTOR: E&E/START
DRILLED BY: A. Jensen
DRILLING METHOD: GEOPROBE DIRECT PUSH
VERTICAL DATUM:
LOCATION: BLACK BUTTE MINE

PROJECT: Black Butte Mine
TDD #: 05-04-0005
PROJECT LOCATION: Cottage Grove, Oregon
EPA PROJ MGR: M. Callaghan
START-2 PROJ MGR: E. Lynch
E & E PROJ #: 001281.0478.01IA

ELEVATION	DEPTH (feet)	USCS	GRAPHIC LOG	SOIL DESCRIPTION	SAMPLE COLLECTION TIME	SAMPLE ID	COMMENTS
				Top of Ground Surface (GS) Elevation			This log is part of the report prepared for the named project and should be read together with that report for complete interpretation. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplification of actual conditions encountered.
	0–0.5	ML		Native Soil - Silt; Grayish purple.	1655	MP07SS04	
	0.5–1.2	CL		Native Soil - Silty clay; Brown			
	1.2–4.0	ML		Native Soil - Silt - clay mixture; Mottled gray - rusty brown			
	4.0						Total depth 4 feet BGS; Abandoned by backfilling to surface with 3/8 inch bentonite chips.

START BBM BORING LOG BBM2005.GPJ E&E PORTLAND.GDT 1/20/06

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*** DRAFT ***

2003, U.S.ACE study published in the report: "Sources and Chronology of Mercury Contamination in Cottage Grove Reservoir for U.S. Army Corps of Engineers, Portland, Oregon" by L.R. Curtis, Oregon State University, May 20, 2003; also demonstrates that the BBM is the source of mercury contamination found in the Cottage Grove Reservoir. On page 37 in the Conclusions Section, the report states "Elevated mercury concentrations in soils surrounding the Black Butte Mine supports the conclusion that the Black Butte Mine is a point source of contamination to the reservoir".

<u>EPA Site Activities:</u>

In July 2004, ODEQ asked EPA to conduct a removal assessment.

September 2005, EPA OSC Mark Callaghan and START completed a Removal Assessment which characterized mining-related impacts. Sampling data was collected from the five main areas: the Main Tailings Pile, the New Furnace area, the Old Furnace Area, the three creeks (Dennis Creek, Garoutte Creek, Furnace Creek), Dennis Creek Adit and the "404" Adit. Results indicated four of the areas should be addressed due to mercury contamination getting into the watershed or potential direct human contact.

May 2006, OSCs Parker and Kitz performed a Removal Assessment site visit with ERRS, START and ODEQ Bryn Thoms.

June 27, 2007 Removal Action Memo signed by Dan Opalski

August 20 to September 5, 2007 OSC Kathy Parker conducted Removal Action with 10 ERRS, 4 START and performed the following tasks: reduced slopes of east and west main tailings piles over Dennis Creek and installed sediment controls; capped contaminated soils around the New Furnace Structure and blocked off the road to the area; removed trees and brush over Old Furnace area and capped contaminated soils and mining artifacts; delineated mercury contamination in Furnace Creek, Dennis Creek and Garoutte Creeks using on-site analysis by XRF and Lumex instruments.

Significant mercury contamination remains in the Furnace Creek bed and slopes.

- Samples were collected in the creek bed and slopes above the creek every 15 feet for the length of the creek. Mercury concentrations above 10 ppm were seen for 1030 linear feet of creek bed and slopes.
- The depth of contamination in the creek bed was over four feet in the two test pits dug in the creek bed and the mercury concentration increased with depth (hole#1 at 4 foot depth was 384 ppm, hole#2 at 3 foot depth was 2926ppm). No native soil was reached.
- A nine foot test pit was dug in the top of a tailings pile overlooking Furnace Creek in an attempt to determine the depth of the pile at the apex. Mercury concentration increased with depth to 1205 ppm at nine feet. No native soil was reached.
- A twenty foot trench was dug from the apex of the pile back along the top of the bank to determine where the tailings pile started. No native soil was reached.
- In total 1249 samples were analyzed on-site during the course of the removal action. The average mercury concentration in surface sediment in the bed of the creek in the contaminated stretch was 124ppm and ranged from 21ppm to 486 ppm.

A possible solution for addressing the mercury contamination in Furnace Creek is to lay back all the tailings slopes and cap with clean soil, cap the creek bed with clean material, install and key in filter fabric covered with heavy rock. An estimate for this work is nine months and $5.4 million.

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Appendix B

1952 Aerial Photograph of the Black Butte Mine Site

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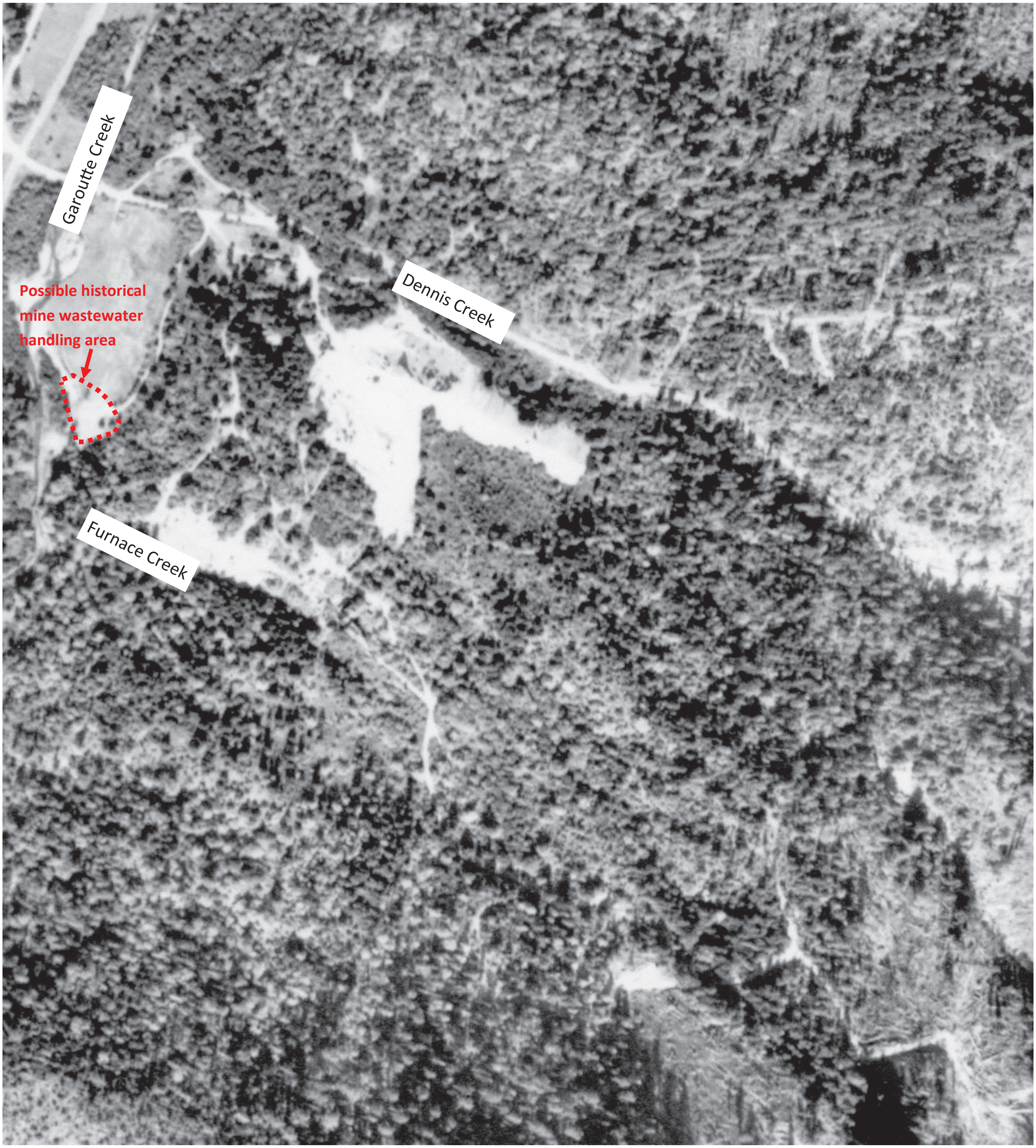
1952 Aerial Photograph of the Black Butte Mine Site



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Appendix C

Elevation Data for the Bottom of Furnace Creek and Upland Groundwater Elevation

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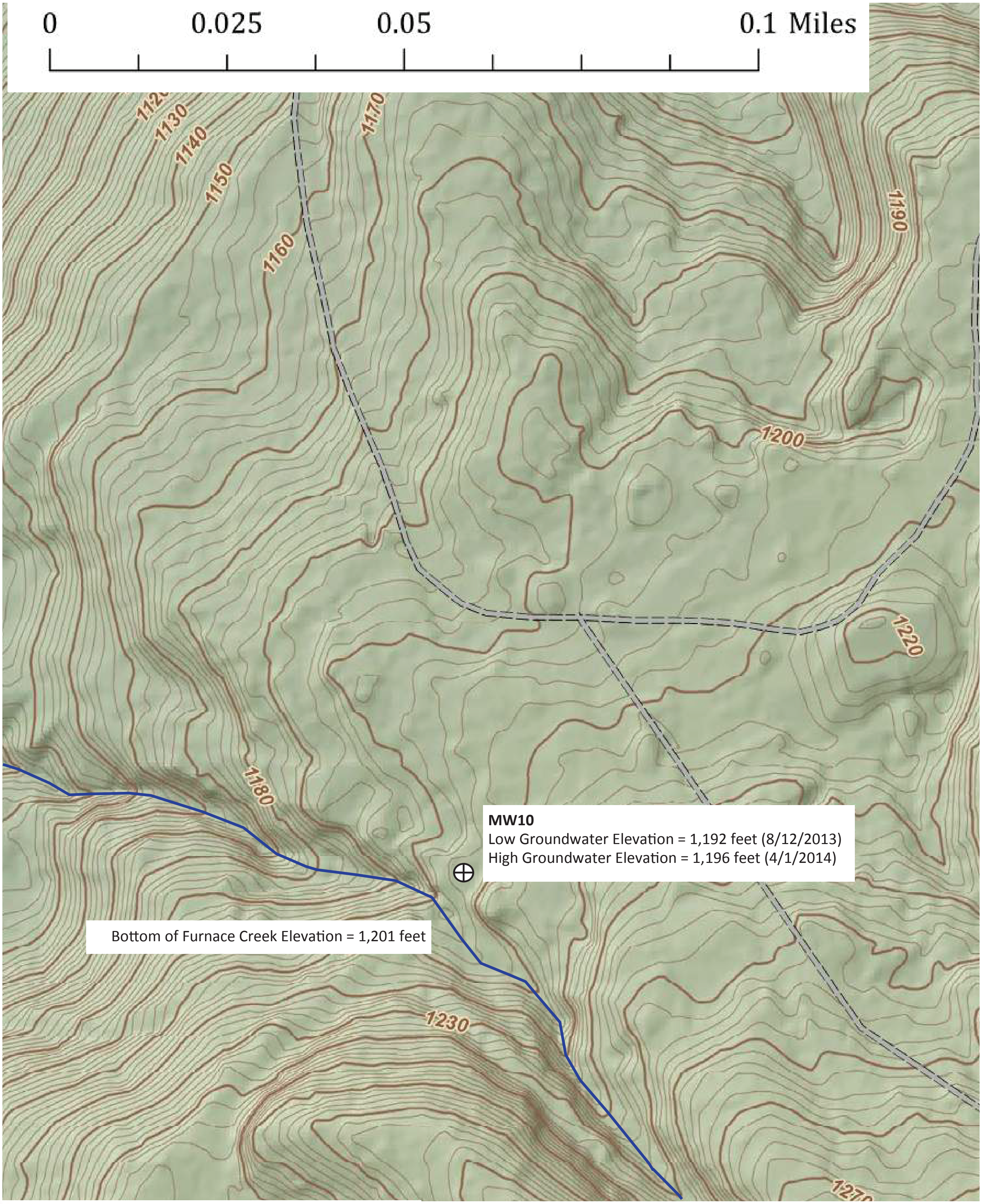

Map for display purposes only. Produced by WSI for CDM Smith.
LiDAR collected April 23, 2013.

Source Data:
- WSI LiDAR derived 2-foot smoothed contours
- WSI LiDAR derived 3-foot bare earth hillshade
- USGS NHD High Resolution Hydrography
- Oregon Spatial Data Library Transportation Network (2012)

Groundwater Elevation at MW10 Versus Elevation of the Bottom of Furnace Creek

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Appendix D

Calculation of Mercury Contribution to Garoutte Creek from Groundwater at MW8

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7/14/2015 H.Y. H. YOUNG

ESTIMATED GROUNDWATER DISCHARGE AND MERCURY FLUX NEAR MW8 BLACK BUTTE MINE SUPERFUND SITE. OU1

ASSUMPTIONS

- PREFERENTIAL FLOW OF GROUNDWATER AT MW8 OCCURS IS THE FORMER CHANNEL/MEANDER OF GAROUTTE AT WHICH THE WELL IS INSTALLED. SOIL TYPE IN THE CHANNEL HAS NOT BEEN CHARACTERIZED BY BORINGS BUT BASED ON MATERIAL OBSERVED IN GAROUTTE CREEK SURFACE AND CHANNEL DEPOSITS IN MW2 & MW3, ASSUME SAND WITH GRAVEL (SW), LESS THAN 10% SILT.

- HYDRAULIC CONDUCTIVITY OF CHANNEL DEPOSITS = $\boxed{K = 134\ FT/DAY}$ (EPA 1986). (COARSE SAND TO COARSE GRAVEL W/ SLIGHT SILT)

- HORIZONTAL HYDRAULIC GRADIENT = $\boxed{I = 0.020}$ BASED ON FLOODPLAIN GROUNDWATER ELEVATION CONTOURS FOR AUGUST 12-14, 2013 LEVEL MEASUREMENTS.

- CROSS SECTIONAL AREA
  BEDROCK IS AT 13 FEET BGS AT NEARBY MW4 & MW5; BASED ON THIS:
  CROSS-SECTIONAL AREA = (DEPTH TO BEDROCK) * (WIDTH CHANNEL)

$$A = (13') \times (30')$$
$$\boxed{A = 390\ FT^2}$$

DARCY'S EQUATION FOR SPECIFIC DISCHARGE IS DISCHARGE(Q) = K A I

$$Q = (134\ FT/DAY)(390\ FT^2)(0.020) = 1045\ FT^3/DAY$$
$$\boxed{Q = 5.4\ gpm}$$

CONCLUSION:

A TOTAL OF 2,838,240 GALLONS PER YEAR IS ESTIMATED FOR GROUNDWATER DISCHARGE TO GAROUTTE CREEK AT AREA NEAR MW8.

ESTIMATED FLUX/ LOADING OF MERCURY TO GAROUTTE CREEK VIA GROUNDWATER DISCHARGE NEAR MW8

ASSUMPTIONS:

DISSOLVED MERCURY CONCENTRATION IN GROUNDWATER = 180 ng/L
(BASED ON MAXIMUM DETECTION AT MW8 ON 5/16/2014).

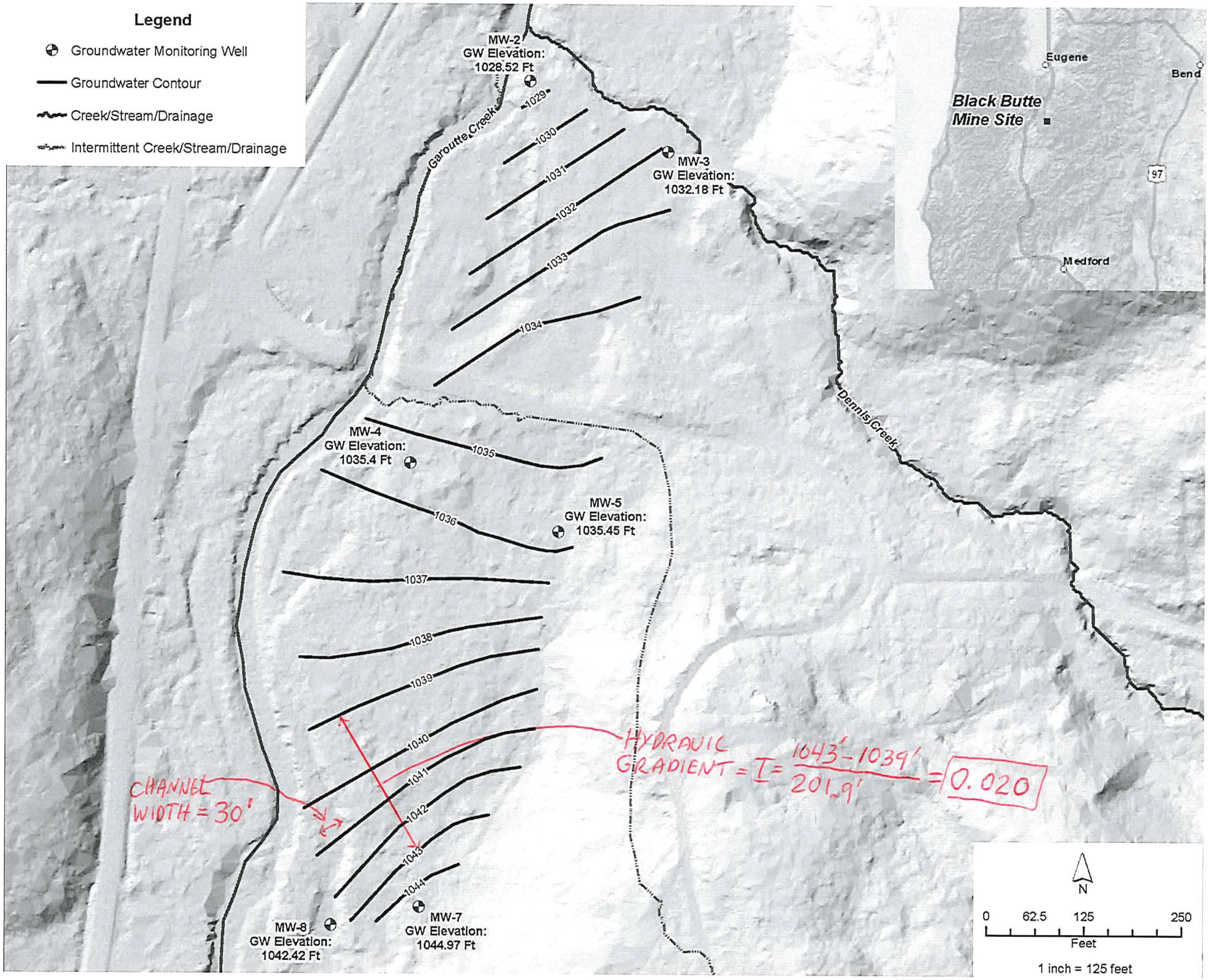
GROUNDWATER DISCHARGE RATE TO GAROUTTE CREEK = 2,838,240 GALLONS/YEAR
(SEE PREVIOUS PAGE FOR CALC + ASSUMPTIONS)

ANNUAL MERCURY LOADING TO GAROUTTE CREEK VIA DISCHARGE OF GROUNDWATER IN MW8 AREA: = (DISSOLVED MERCURY CONCENTRATION AT MW8) X (ANNUAL GROUNDWATER DISCHARGE TO GAROUTTE CREEK)

$$\text{ANNULAR MERCURY LOADING FROM GROUNWATER} = \left(\frac{180 \text{ ng}}{\text{L}} \cdot \frac{1 \text{ Kg}}{1{,}000{,}000{,}000{,}000 \text{ ng}} \cdot \frac{2{,}838{,}240 \text{ gallons}}{1 \text{ YEAR}} \cdot \frac{3.785 \text{ L}}{1 \text{ GALLON}} \right)$$

$$\boxed{\text{ANNULAR MERCURY LOADING FROM GROUNDWATER NEAR MW8} = 0.0019 \text{ Kg/YEAR}}$$

THE TOTAL LOADING TO GAROUTTE CREEK IS LESS 1% OF THE ANNULAR MERCURY LOAD IN ~~1K/DOWNLEA~~ DOWNSTREAM GAROUTTE CREEK, WHICH WAS ESTIMATED AT 0.74 Kg/YEAR.



All water level data collected synoptically on August 12, 2013 except for MW8 which was measured on August 14, 2013

CDM Smith

Black Butte Mine Superfund Site

Figure 3.5-1
Groundwater Level Contours
(August 12, 2013)

3 of 4

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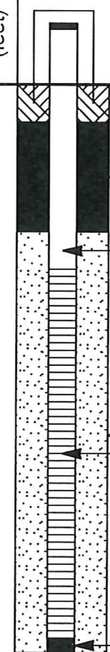
PROJECT: Black Butte Mine Superfund Site	NO:	MW-2
LOCATION: Cottage Grove, Oregon	U.S. EPA	

STARTED:	6/20/13 COMPLETED: 6/20/13	NORTHING:	NA	EASTING:	NA
DRILLING COMPANY:	Cascade	G.S. ELEVATION:	NA	M.P. ELEV:	
DRILLING EQUIPMENT:	AMS C-17	WATER:	4.5 NA	TOTAL DEPTH:	15.0 NA
DRILLING METHOD:	Sonic, 6 In. Dia. Borehole	LOGGED BY:	AG		
SAMPLING METHOD:	Core Barrel	HORIZONTAL DATUM: , COORD. SYS.: NA			
SURFACE COMPLETION:	Steel Stickup	VERTICAL DATUM:			

DEPTH (feet)	GRAPHIC LOG	USCS	DESCRIPTION	SAMPLE ID	SAMPLER ADV. (feet)	RECOV. (feet)	PID (ppm)	ELEV. (feet)
		ML	SANDY SILT: dark yellowish brown (10YR 3/4); 50% silt, moist, soft, medium plasticity; 40% sand, fine to coarse, subangular to subrounded; 10% gravel, fine to coarse, subangular, maximum diameter 1.5"; trace cobbles. Cobble layer at 3 ft bgs.					
5		SW	SAND with GRAVEL: dark reddish-brown (5YR 3/4), 65% sand, fine to coarse, well graded, subangular to subrounded; 30% gravel, fine to coarse, well graded, subangular, maximum diameter 1.5", 5% silt					
		SW	SAND with GRAVEL: dark yellowish-brown (10YR 3/4), 60% sand, fine to coarse, well graded subangular to subrounded; 40% gravel, fine to coarse, well graded, angular to subangular, maximum diameter 1.5"; trace silt					
10		SM	SILTY SAND: black (5Y 2.5/1); 70% sand, fine to coarse, well graded, subrounded; 30% silt, soft, wet					
		ML	SANDY SILT: dark yellowish-brown (10YR 3/4); 60% silt, moist, high plasticity, firm; 40% sand, fine to medium, subangular, trace gravel, maximum diameter 1"					
15		ML	SANDY SILT: black (10YR 2/1) 60% silt, moist, low plasticity, firm; 40% sand, fine to medium subangular, trace gravel; maximum diameter 1/2"					
20								
25			Boring terminated at 10 ft bgs					
30								
35								

ASSUME TYPICAL OF GAROUTTE CREEK CHANNEL DEPOSIT.

WELL CONSTRUCTION (From - To Interval, feet bgs)



PROJECT NO. 50898-92004

WELL CONSTRUCTION LOG

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